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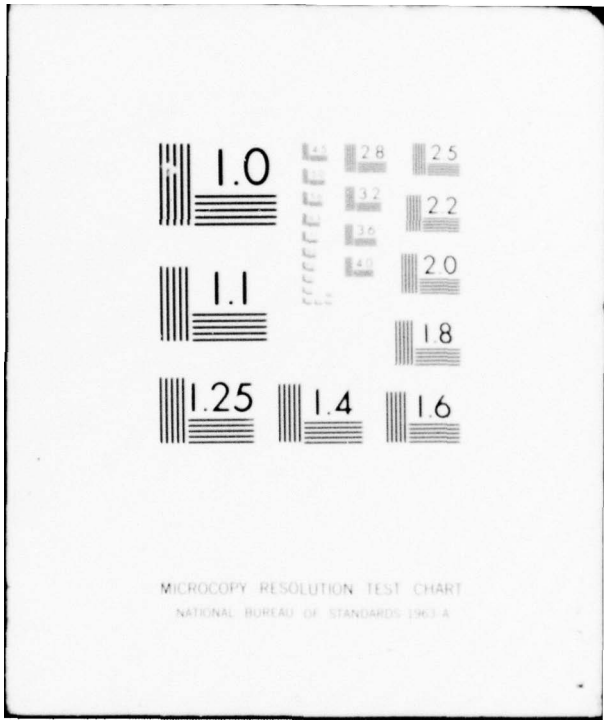
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This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists by disclosing interesting information well in advance of the usual scientific publications.

The articles are written primarily by members of the staff of ONRL, with certain

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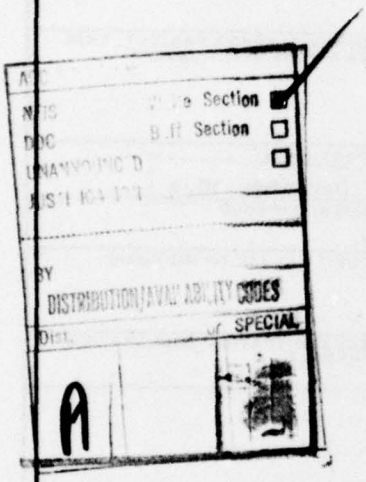

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BEHAVIORAL SCIENCES

PSYCHOLOGY AND DIVER PERFORMANCE ASSESSMENT IN OSLO

The University of Oslo is one of 4 universities in Norway. It was founded in 1811 as the Kongelige University, and was renamed in 1939. The other 3 universities are young by comparison, as the oldest was formed in 1948 and the other 2 as recently as 1969. The University of Oslo has a student body of about 19,000 with a faculty numbering 1407. As a State Institution, its financial support comes wholly from the Government.

The Department of Psychology, which administratively is within the Faculty of Social Science, has a staff numbering less than 10 and is heavily oriented towards clinical psychology and psychotherapy. The chairmanship of the Department (which is rotated among the faculty) currently is held by Professor Ulf Kragh. Kragh is known in the clinical field, among other things, for the development of the Defense Mechanism Test (DMT) which he first published in 1960. The DMT is a projective technique for clinical diagnosis and personnel selection. It is administered as a group test, and the techniques consist roughly of presenting a repeated subliminal exposure of a picture showing a central "hero" and a peripheral threatening person. After each exposure, the subjects are required to make a sketchy drawing (or a marking) of what they have seen and to write a short comment. The DMT has been used to diagnose defense mechanisms and to predict the ability of individuals to perform various tasks under conditions of stress. It has been used in the past to predict the performance of aviation cadets in flight training and for the selection of Danish attack divers, as well as in a variety of other situations.

One of the few programs in the Psychology Department not directly involving clinical psychology is one of visual research being carried out under the direction of Ivar Lie, a professor of sensory psychology. Lie is developing several tests to be used for testing the visual functioning of small children beginning at the age of 2 years. One such test involves presenting a sequence of moving vertical lines to the child. As the lines move past the visual field, the examiner observes the child's eyes to see if nystagmus (a rapid involuntary oscillation of the eyeballs) is present. If it is, it means that the child can visually resolve the separation between the lines. The separation of the lines as well as their width can readily be varied so that an accurate measure of visual acuity can be obtained without the child being required to read letters of the alphabet.

Lie also is developing and using a test to measure the visual field of small children. In this instance he is using various cartoon figures and animal pictures as visual targets in the periphery of the visual field, rather than standard eye charts. Still another area of investigation involves the measurement of visual acuity of patients with cataracts. Lie has found that although the visual acuity of persons with cataracts may appear satisfactory when tested with the usual eye charts, they may have considerable difficulty in seeing adequately in situations in which the contrast between the figure and its background is reduced. Using standard Snellen Es, dots of various sizes, and other measures of acuity, Lie is conducting experiments in which such test objects are viewed under conditions of varying background and target illumination. These experiments are still in progress and results are not yet available as to which illumination combinations are most favorable.

While in Oslo, I also had the opportunity to visit the EEG (Electroencephalographic) Institute in the suburb of Gaustad. Its Director, Dr. C.W. Sem-Jacobsen, has been conducting studies for years in the laboratory and in the field relating to the effects of stress on various bodily functions, particularly cortical activity. He has had several contracts with the US Department of Defense, the last of which is an ONR contract which is terminating in November 1976. He has developed special field packages for measuring EEG, heart rate, as well as other biomedical parameters in real-world situations such as parachute jumping, flying, and diving. In addition, Sem-Jacobsen has developed a biomedical seat pad capable of monitoring the ECG (electrocardiograph) of a pilot without requiring the attachment of any leads or sensor devices to the body. The

pad, which requires no power source, obtains ECG signals transmitted to it through the pilot's pants and his perspiration. A good quality ECG signal is obtained when conductive strips are disposed on top of a nonconductive waterproof sheet; in this way sufficient peripheral perspiration is retained for adequate electrical conductivity to operate the sensor. The data so obtained may be transmitted directly online from an aircraft to ground control by use of available space on a transmitter or radio channel. Further details on this device may be obtained from the *Journal of Aviation, Space, and Environmental Medicine*, April, 1976.

One of the reasons for visiting Sem-Jacobsen was to attend a series of meetings he had arranged for the purpose of discussing the performance of divers employed in the inspection of offshore platforms. Participants in these meetings represented the principal Norwegian diving company involved (Stolt-Nielsens Rederi A/S), Phillips Petroleum, Det Norske Veritas, the Directorate of Labor Inspection and the Norwegian Underwater Institute. For reasons of safety, operation, and insurance, the structural integrity of offshore structures must be verified by divers on a regular basis. This requires them to work at depths up to 500 to 600 ft in cold, dark and turbid waters. It is known from numerous studies, as well as from practical experience, that the judgment and memory of divers can be adversely affected when working under such conditions. Some of the tasks involved in such inspections require the diver to detect small cracks, to measure distances between structural members, and to detect other signs of structural fatigue or damage. Even though each dive is carefully planned and specific areas to be inspected identified prior to the dive, there is still the need for visual inspection and applying judgment in order to carry out the job properly. Considering the conditions under which they work, the divers apparently are reported to be doing remarkably well. However, with the increase in the number of structures, coupled with the fact that some have been in place in the North Sea for 4-5 years, the number of inspection divers required will increase. Thus, there is a need for improved diver selection and training.

Sem-Jacobsen has been asked by some of the Norwegian organizations responsible for offshore inspections to suggest ways of assessing the performance and judgment of inspection divers so that the data they obtain can be relied upon. During my visit to Norway a number of possible ways in which the diver could be aided were discussed and a review of the techniques now in use was made at the meetings mentioned earlier. Because there are no existing performance tests which can accurately predict the ability of divers to carry out inspection tasks, one approach suggested by me was to place an unused structure or parts of structures having known defects in the fjords and have divers inspect them. Various methods of inspection could be compared, including visual inspection, reporting (either verbally or by note-taking), remotely-controlled moveable television cameras, television cameras permanently mounted at strategic points on the structure, a helmet-mounted television system worn by the diver with the monitor on the surface (such a system is commercially available) where the diver is directed by a surface supervisor, an armored diving suit such as JIM (see ESN 30-9:416-420), or a submersible vehicle. It is anticipated that a program will be developed in the next few months to examine the techniques suggested by me and actually to train and evaluate diver inspection performance.

If this training and selection program materializes, as expected, it is the intention of Sem-Jacobsen to utilize his experience and the techniques he has developed for the biomedical monitoring of pilots and divers, for assessing the physiological state of inspection divers and to correlate the data obtained with their performance. He has developed a comparable self-contained biomedical recording package worn by the diver which avoids the need for extra umbilicals and electrical leads.

The turbulent nature of the North Sea is such that the oxygen content of the water is fairly uniform all the way to the bottom. This means that corrosion can occur to depths greater than those to which it is limited in calmer waters. Consequently, inspection divers must go deeper to carry out their job. For these reasons any assistance which can be provided through improved selection or training procedures, or by better inspection, is of great importance. (J.W. Miller)

ROBOTS AND MANIPULATORS

Warsaw, Poland was the site of the Second International Symposium on Theory and Practice of Robots and Manipulators. This conference which took place from 14-17 September was sponsored by the Centre International des Sciences Mécaniques (CISM) and the International Federation for the Theory of Machines and Mechanisms (IFToMM) in association with the Technical Division of the Polish Academy of Sciences.

The 150 invited participants were from 11 different countries. The meeting was held at the Conference Center for Civil and Mechanical Engineers, located in Jadwisin, approximately 20 miles outside of Warsaw. While the facilities were fine, the lack of frequent transportation to and from Warsaw created some problems for the participants including the writer, who on the first trip to Jadwisin from Warsaw felt he was playing a part in a Peter Sellers movie. A local city bus driver inadvertently put me off at the wrong place and I found myself (wearing coat, tie and carrying a black briefcase) strolling for 2 miles down a pleasant but dusty remote country road unable to communicate with the local inhabitants. After I had been mis-directed by a helpful young man with a very severe speech impediment, my adventure ended happily when I was offered a ride in a jeep to the meeting, but there were a few moments for introspection as to why I was doing what I was doing.

The technical sessions, which were all in English, were divided into 9 categories: Mechanics, Biomechanics of Motion, Synthesis and Design, Walking Machines and Orthotic Devices (aids for the handicapped such as braces, etc.), Control of Motion, Sensors, Artificial Intelligence, Man-Machine Systems and Applied Robotics. There also were some special panels and evening informal discussion sessions.

Recent advances in technology have greatly increased our capability to develop robotic systems having almost any configuration one might think of. Partially as a result of such advances, several speakers raised the question as to how far we should go in attempting to imitate the human appendage system. Prof. A. Morecki (Tech. U. Warsaw) described a study in which the possible combinations of functions of the lower and upper extremities of mammals and birds were analyzed. He concluded that "nature has selected only certain interrelated combinations among all possible ones--and that direct copying even of small parts of living organisms seems to be neither purposeful nor possible considering the complications of supply and energy transformation in living organisms."

Several speakers described walking vehicles having various numbers of legs ranging from 2 to 8. A.P. Bessonov (Inst. for the Study of Machines, Moscow) analyzed the relationship between the number of possible gaits of a walking vehicle and the number of its legs. He related his study to the use of such vehicles for off-road mobility and in various industrial situations. He pointed out that although 2-legged walking vehicles have been developed, he felt that "multilegged robots appear to be more (sic) preferable for they permit the vehicle to move in a state of continuous stability, hence, increasing its reliability."

K. Taguchi (Automobile Division, Mech. Engrg. Lab., Suginami, Tokyo) described a program underway to develop quadruped locomotion machines for off-road mobility. He showed movies of a working model of such a device. He is experimenting with different gaits and leg configurations in order to develop a system that has adequate stability in all walking and standing modes. One of the fundamental problems he finds is how to simplify the subsystems involved in sensing, recognizing, controlling, etc. While his work is far from being finished, he feels at this time that the use of a fluid-type digital actuator as a driving mechanism will provide the most reliable motion and stability. A paper was presented by D.E. Okhotsimsky (Inst. Applied Mechanics, USSR Academy of Sciences, Moscow) concerned with the problem of synthesizing control algorithms for a 6-legged automatic walker which is able to perceive geometrical characteristics of the environment. The movie showing a dynamic computer simulation of such a device was quite impressive. Using what is basically a terrain-avoidance system, the walker avoided obstacles, turned, stopped, etc. Okhotsimsky believes that "an efficient configuration of the walker should involve a 'rectangle' (sic) body and 6 equal,

symmetrically positioned, three-degree-of-freedom legs" which should enable it to walk and climb over rough terrain.

Other presentations were made in which walking or exoskeletal devices were described. While many approaches are being considered, the progress to date tends to support the use of a 6-legged device for off-road mobility.

Several papers were presented pertaining to the development of prosthetic and orthotic devices. Of particular interest was one given by M. Vukobratović (Mihailo Pupin Inst., Belgrade, Yugoslavia), who described a current program that has as its objective the development of a new method for the "synthesis of nominal dynamic states of artificial motion." He demonstrated his concepts by showing movies of an anthropomorphic exoskeletal leg mechanism. This device, which is basically a walking machine, may be worn by a man who has lost the use of his legs. The machine actually does the walking and the wearer is to a large degree a passive element in the system. The movies showed the machine in use including "walking" the wearer up and down stairs. The ultimate goal of this program, according to Vukobratović, is to enable a patient with no leg control to walk assisted only by 2 canes and the machine. Vukobratović recently has published a monograph entitled *Legged Locomotion Robots and Anthropomorphic Mechanisms*. This 630-page book can be obtained from the Mihailo Pupin Institute, Belgrade, POB 906 for approximately $23.00.

J.W. Hill (Stanford Res. Inst., Menlo Park, CA) described a lower-limb orthotic system which he developed while on leave to the Unité de Recherches Biomécaniques, Montpellier, France. This system is similar in concept to Vukobratović's in that it requires the patient to maintain his balance with canes as the movements of his legs are controlled by the device. The system is designed to permit a paraplegic to make both forward motion and standing-up and sitting-down motion. According to Hill, a basic difference between this and other systems is that stability is maintained by the patient with his canes and not by the control system. Thus the power need only move the legs through the required walking or sitting-standing trajectories with the patient balancing and steering himself. Hill's efforts thus far indicate that hydraulic actuators have several advantages over pneumatic ones, e.g., they are lighter and smaller, less noisy, safer because there is no stored energy in the cylinders, and they provide greater torque for their size.

While concern was expressed over what some participants viewed as a slow growth rate in the use of robots, several of them pointed out that the present rate is about right. J.F. Engelberger (President, Unimation Inc., Danbury, CT), whose company has produced about 20% of the robots currently in use in the world, feels that the field is still in its embryonic stage. He is of the opinion that the future (from the standpoint of investment and profit), at least for the next few years, lies in industrial robots because there is not sufficient financial support for the development of exoskeletons and prosthetic devices.

Several presentations were devoted to describing industrial robots and their growing impact on manufacturing procedures. H.J. Warnecke (U. Stuttgart, FRG) pointed out that industrial robots would be in wider use if they could be introduced without requiring significant changes in existing workplace layouts. At the present time there are about 5500 industrial robots in use throughout the world: 2000 in Japan, 2000 in the US, and 1500 in Europe. Generally speaking, robots are finding employment in situations in which men are exposed to a dangerous environment or where a job is routine and monotonous. Films were shown of various industrial situations including a 30-minute movie from the Soviet Union showing the YM-1 robot in use in a factory performing such tasks as welding and moving things from one location to another.

One of the problems pertaining to the use of industrial robots is that the user frequently does not know how to specify his needs to the robot manufacturer. There is, according to T.B. Sheridan (MIT, Mass.), a real need for performance criteria, a glossary of terms, and some generalized procedures. Sheridan is not in favor of issuing standards or regulations at this time, however, because such action could have the effect of discouraging research and advanced development.

A particularly interesting presentation was made by M.W. Thring (Queen

Mary College, U. London) in which he stressed the use of robots in the mining of coal. He feels that the world's energy crisis could be alleviated to some extent if we spent more "energy" money in developing automated coal-mining procedures. Thring expressed the opinion that one reason coal is not mined in greater quantities is because of the health hazards confronting the workers. Existing robot technology could be put to use in such a way that miners would not be exposed to the hazards historically associated with coal mining. As if in response to Thring's comments, in one of the evening film sessions a movie was shown of a recently developed wheeled robot, with force feedback control, that was specifically designed for coal mining. Such a device would be particularly appropriate for Poland which supplies about 12% of the world's coal.

In summary, the meeting left one with the feeling that the field of robotics is maturing and growing in a steady way. While some of the devices described are a little far out, the technology represented shows real innovation which undoubtedly will find application in the future. (J.W. Miller)

CHEMISTRY

SEVENTH INTERNATIONAL MASS SPECTROMETRY CONFERENCE

The Seventh International Mass Spectrometry Conference was held in Florence, Italy, from 30 August to 3 September 1976. Formal proceedings will be published by the Institute of Petroleum; the editor is predicting a publication date of early 1977. If this date is met, the editor, Dr. Norman Daly of the Admiralty Weapons Research Establishment (AWRE), Aldermaston, will receive a well-earned vote of thanks from the Mass Spectrometry community. The Conference was sponsored by the Mass Spectrometry organizations of Australia and New Zealand (ANZSMS), Belgium, Canada, Denmark, France (GAMS), Germany (AGMS), Great Britain (HRG/IP), Italy (GSM/SCI), Japan (MSSJ), The Netherlands, Norway, Sweden, Switzerland, USSR, US (ASMS), and Yugoslavia. More than 600 delegates from 43 nations attended this very popular meeting. The host country, Italy, and Germany tied for the lead for the number of delegates with 111 from each nation.

The Conference featured 10 plenary lectures covering topics ranging from the "Unimolecular Decomposition of Polyatomic Ions: Decay Rates and Energy Disposal" by Professor C. Lifshitz (Hebrew U., Jerusalem) to "Biomedical Applications of Mass Spectrometry: Clinical Use of Stable Isotopes" by Professor J. McCloskey (Dept. Biopharmaceutical Sciences, U. Utah). In addition, there were 197 contributed papers in the areas of biochemistry, organic chemistry, molecular fragmentation, instrument development, new spectroscopic techniques, computer applications, biochemical applications, high temperature chemistry applications, field ionization, ion molecule reactions, and theoretical aspects of mass spectrometry. Ninety-nine poster papers were delivered. This is the first time that poster papers have been given at these meetings, and, in the authors' opinion, this method of scientific communication was very successful. It was particularly useful in conversing with people who did not speak fluent English, the official language. There were also 7 round-table discussions over the subjects of mass spectral interpretation, pumping techniques for mass spectral applications, high accuracy isotope dilution, high pressure liquid chromatography and mass spectrometry, secondary ion mass spectrometry, application of mass spectrometry to medical problems and sequencing of biological molecules, and new developments and trends in mass spectrometry. Thus, there were a total of 313 mass spectrometry presentations at this 5-day Conference covering all the major areas of active mass spectrometry research compared to 136 contributions at the last Conference in Edinburgh 3 years ago.

Lifshitz presented a far-reaching review on the basic principles of unimolecular decomposition of polyatomic ions, stressing decay rates and energy disposal routes. She emphasized that, while progress has been made in the last few years, much remains to be learned. She believes future research in unimolecular decomposition looks very promising with the use of new techniques employing lasers and other methods of creating ions in specific, well-defined energy states. Dr. J.

Franzen (Varian MAT, Bremen, FRG) gave a plenary lecture on instrumental development and data-processing advances in the past 3 years. Franzen stressed that what is really needed in mass spectrometry instrumentation today is the development of low-cost, small, highly reliable mass spectrometers--the type that could be put in garages, hospitals, and other areas for routine use. He noted that several groups are working towards this end.

Prof. K.R. Jennings (Dept. Molecular Sciences, U. Warwick, Coventry) discussed the recent developments in the study of ion-molecule reactions. Like Lifshitz, Jennings also mentioned several elegant experiments, such as the flowing afterglow work by which Ferguson and Fehsenfeld have determined rates of ion-molecule reactions at thermal energies. These rates are necessary in order to understand the chemistry of the upper atmosphere. Prof. J. Beynon (Dept. Chemistry, U. Coll. Swansea, U. Wales) discussed unimolecular and collisionally-induced reactions in a most elegant and entertaining fashion. In particular he discussed the new technique of ion kinetic energy spectroscopy and its application to the elucidation of the fragmentation pathways of ions. The two plenary lectures by Jennings and Beynon covered the field of ion-molecular reactions in a thorough manner. When these papers appear in the Conference proceedings, they should be read very carefully by everyone who is working in the field of ion-molecule chemistry.

The plenary lecture given by Dr. J. McCloskey (Dept. Biopharmaceutical Sciences, College of Pharmacy, U. Utah) on biomedical applications of mass spectrometry and clinical use of stable isotopes pointed out some of the more important and interesting aspects of mass spectrometry in this context. For example, drugs can be labelled with ^{13}C, and their metabolic pathways followed by mass spectrometric analysis. This method is especially important for human subjects where radioactive ^{14}C cannot be used.

The plenary lecture by Dr. P. DeBièvre (BCMN, Uratom Geel, Belgium) described experimental techniques used to measure isotope ratios. DeBièvre emphasized strongly the importance of determining the amount of cross-contamination and memory effects which occur in the mass spectrometer.

Prof. D.H. Williams (U. Chemical Laboratory, Cambridge) lectured on how to determine the molecular structure of a complex organic molecule from the molecule's fragmentation. Using stable isotopes such as deuterium Williams put together the "jig saw" puzzle of alkaloid molecules.

The final plenary lecture of the meeting was by Dr. J. Freudenthal (Rijks Instituut Voor de Volks Gezondhied of Viltohoven, The Netherlands) who reviewed environmental applications of mass spectrometry. He felt that for many problems capillary gas chromatography columns were a necessity and would become the standard type of column used for GCMS in the next few years. He was quite concerned with the increasing amounts of polychlorinated biphenyls (PCBs) he was finding in virtually all of the samples he had analyzed in the last few years. This was an excellent review of the environmental chemistry which is being carried out in Europe.

The sessions of contributed papers, dealing with biochemical applications (such as sequencing of peptide molecules), computer applications, negative ion chemical ionization, field desorption, and the progress made in the interpretation of secondary ion mass spectrometry (SIMS), were very popular among the delegates at this Conference. Prof. V.L. Tal'rose (Institute of Chemical Physics, Academy of Sciences of the USSR) described his laboratory's work dealing with capillary systems for the continuous introduction of liquids into analytical mass spectrometry. The novelty of this work is the preparation of glass or silica capillaries with round sections approximately 10^{-4} cm in diameter and 1-10 cm long. Copper capillaries with slit sections which have the dimensions of 10^{-5} to 10^{-6} cm and 10^{-1} cm long are also being used in this study. Tal'rose showed that these capillary systems make it possible to analyze mixtures containing components of high absorption properties. For example, mixtures of carbocyclic acids were directly analyzed for the first time. This work, of course, has potential application in the coupling of a high pressure liquid chromatograph to a mass spectrometer. A workshop in the area also stimulated a great amount of interest.

Dr. D.L. Cocke, G. Abend and Prof. J. Block (Fritz Haber Institut, Max-Planck-Gesellschaft, Berlin) reported on applications of a technique that Block discussed at this Conference three years ago in Edinburgh, i.e., the use of a field ionization time-of-flight mass spectrometer. At this meeting, Cocke used this approach to study the kinetics of the reactions of elemental sulphur. He used field ionization to follow the reaction of S_2 molecules as they form polymeric sulfur molecules (S_x) on the surface of his emitter. The S_2 molecules were produced by an electrochemical Knudsen cell and directed at a tungsten field emitter.

Prof. Donald F. Hunt (Dept. Chemistry, U. Virginia) and his co-workers, F. Crow, T.M. Harvey and T. Knudsen, described their exciting work on the analytical applications of negative ion chemical ionization (CI) mass spectrometry. Hunt, who has been a leader in innovative instrumental approaches to CI and also in the use of novel reagent gases, described a new CI approach which can simultaneously detect positive and negative ions. This paper drew favorable comments throughout the Conference. Hunt showed that some of the ion currents obtained by the negative ion mode are a thousand times greater than their positive analog.

The group headed by M.G. and E.C. Horning and co-workers (Institute for Lipid Research, Baylor College of Medicine, Houston) presented papers on the studies of negative ions by atmospheric pressure ionization. Atmospheric pressure ionization, which was invented at Horning's laboratory, greatly increases the sensitivity of mass spectrometry, allowing the study of many low volatility samples. In this technique, ionization is caused by bombardment of the molecule with high energy electrons from a nickel-63 source or a corona discharge. The ionization results in both positive and negative ions as well as low energy secondary electrons. These thermal electrons attach to molecules by electron capture processes. Thus, the Baylor group is able to study the negative ions of some very complex molecules such as allyl substituted barbiturates.

Another extremely popular contributed session was the one on ionization of non-volatile compounds. The presentation by F.W. Röllgen, U. Giessmann and H.R. Schulten (Inst. Physical Chemistry, Bonn) on the ionization of polar organic molecules by alkali ion attachment on surfaces was particularly fascinating. Stable "quasimolecular ions" are obtained when alkali ions attach to polar molecules. Röllgen postulates that the reason for the stability is the localization of the positive charge on the alkali ion. The advantage of this technique, as compared to attachment by hydrogen, such as occurs in chemical ionization, is the efficiency with which these alkali ions attach to the molecules. It was reported that lithium iodide (LiI) was the best reagent salt for the polar molecules.

Two other new ionization methods were also reported. The first was Time-of-Flight Mass Spectrometry of Non-Volatile Organic Compounds by Fast, Heavy, Ion-Induced Volatilization and Ionization. F.R. Krueger and K. Wien (Inst. für Technische Kernphysik, Darmstadt, Germany) discussed their research, an extension of the work originally reported by R.D. MacFarlane, which uses high-energy fission fragments from Californium-252 that pass through a thin foil on which a non-volatile organic substance has been deposited. The organic substance is volatilized and partially ionized. Positive and negative ions are observed. At this time the technique of ionization looks promising. However, the process is not understood and much work remains before it can be an accepted analytical technique.

Finally, the use of phase-angle mass spectrometry to study the vapor of $(SN)_x$ was described by the authors of this report. $(SN)_x$, which is a non-metallic superconductor, was reported to form a new linear $(SN)_4$ species when it is sublimed.

Overall, the meeting was a great success. The delegates left Florence expressing their appreciation to Dr. S. Facchetti for his outstanding work as chairman of the organizing committee and they are looking forward to the next international triennial meeting in 1979. (F.E. Saalfeld and J.R. Wyatt, Naval Research Lab., Washington, DC)

GENERAL MEETING OF THE INTERNATIONAL SOCIETY OF ELECTROCHEMISTRY (ISE) IN ZURICH

Now in its 27th year, the International Society of Electrochemistry has emerged as the principal international forum for electrochemistry, both fundamental and applied, through its biennial meetings, yearly symposia and its journal, *Electrochemica Acta*. The Society, based in Geneva, Switzerland, was originally known as the International Committee for Electrochemical Thermodynamics and Kinetics (CITCE), but changed its name in the early 1970s when it took on the more formal structure of a Society.

The international meeting of the Society, held in Zürich on 5-11 Sept 1976 at the Swiss Federal Institute of Technology (ETH) with Professor N. Ibl as General Chairman, was attended by approximately 600 scientists and engineers from 32 countries. Virtually all phases of electrochemistry were represented in the program with special emphasis on 3 main themes: electrochemical engineering, anodic films and passivation layers and experimental methods in electrochemistry. In addition, an IUPAC symposium was held in conjunction with the ISE meeting on the electrochemistry of non-isothermal systems.

The past 2 decades have seen the evolution of electrochemical engineering as a well-respected area of electrochemistry, in good part as a result of the work of Profs. C. Tobias and J. Newman (U. California at Berkeley) and Prof. N. Ibl at the ETH in Zürich and their many students. The impact of this area on electrochemistry as a whole was evident in the invited review area, including those by Newman and Tobias and the various research papers. Quantitative treatments of mass and charge transfer were presented for a wide range of electrode configurations and prevailing conditions with particular emphasis on porous electrodes, flow-through and fluidized-bed electrodes and rotating disk electrodes. Recent developments involving fluidized-bed electrodes were summarized by Prof. Frank Goodridge (U. Newcastle upon Tyne) who, with Prof. M. Fleischmann (U. Southampton), originally introduced the concept. This type of electrochemical reactor continues to offer interesting possibilities for various electrode processes including organic electrode reactions. The quantitative engineering description of this electrode system, however, is very difficult, although some progress is being made.

In his plenary lecture, Prof. P. Gallo (U. Genoa) addressed some of the problems facing the electrochemical engineer with respect to energy conservation in industrial electrolytic processes, space-time yield of electrochemical processes and materials of construction. He summarized recent important developments in electrochemical technology including the introduction of catalyst-coated titanium anodes and ion-exchange membranes in the electrochemical production of chlorine, new processes for aluminum electrowinning, the highly effective technology of electrochemical machining and water desalination by electrodialysis.

Anodic films play an important part both in inhibiting the corrosion of active metals such as the ferrous alloys (the passivation phenomena) as well as in catalyzing various electrode processes. Through a combination of various electrochemical and optical methods, substantial information has been obtained concerning the formation and breakdown of such films as well as their structure. In invited lectures, Dr. H.J. Engell (Germany) discussed the various features of such films, while Prof. R.R. Dogonadze (Inst. of Electrochemistry, Moscow) and Prof. K.E. Heusler (Corrosion Laboratory, Göttingen) summarized recent developments in understanding electron transfer reactions on such anodic films. With thin oxide films on electrodes, electron tunneling through the film plays an important role in controlling various electro-catalytic processes as was pointed out by Prof. J.W. Schultz (West Berlin) in his lecture at the meeting as well as in earlier publications.

In a plenary lecture summarizing important developments in experimental methods in electrochemistry, Prof. R.H. Muller (Berkeley) highlighted various *in situ* optical techniques with emphasis on ellipsometric and optical reflectance spectroscopy for the study of various layers on electrodes and the use of interferometry and ellipsometry for the study of the concentration profiles in boundary layers at electrodes. The power of the *in situ* optical methods was well illustrated in the contributed paper

program which included the use of optical techniques in structural and kinetic studies of electrosorbed species and passivation layers, the investigation of intermediates in electrode processes and the use of interferometric holography to study mass transport in solution. Other developments reported at the meeting in the experimental technique area included the use of low energy electron diffraction and Auger and x-ray photoelectron types of spectroscopy to examine electrode surfaces, both before and after electrochemical measurements with special techniques to minimize changes; the use of noise analysis to examine electrode processes; photoelectrochemical effects of interest from the standpoint of the fundamental electrochemistry of semiconductors as well as solar energy conversion; and micro electrodes for the study of very fast reaction kinetics to minimize mass transport limitations.

Prof. H.W. Nurberg (Institute for Applied Physical Chemistry, Jülich) presented a keynote lecture on the applications of advanced polargraphic and voltammetric methods to environmental studies and the monitoring of toxic metals. Electroanalytical techniques look quite attractive for such applications. (E. Yeager, Case Western Reserve U., Cleveland)

MODERN TRENDS IN ACTIVATION ANALYSIS

The Fifth International Conference on Modern Trends in Activation Analysis was held at the Technical University of Munich, Federal Republic of Germany, 13-17 September 1976. The Conference was organized by the Gesellschaft Deutscher Chemiker, the Institut für Radiochemie der Technischen Universität München and the Gesellschaft für Strahlen- und Umweltforschung GmbH at Neuherberg, FRG. More than 170 papers were presented by authors from 30 different countries during 3 daily parallel sessions plus 2 poster sessions. Conference preprints have been published in English and were available to all participants upon arrival in Munich. It is planned to publish the papers officially in the *Journal of Radioanalytical Chemistry*.

The scientific program was augmented by 4 plenary lectures by H-.J. Born (FRG): "Activation Analysis and Radiochemistry; Comments to their Interrelation"; I.J.T. Davies (UK): "Medical Significance of the Essential Biological Metals"; J.W. Morgan (US): "Chemical Fractionation in the Solar Systems"; G. Baudin (France): "Analytical Methods Applied to Water Pollution." Another plenary lecture by Yu. V. Yakovlen (USSR): "The Influence of Different Factors on the Result of Activation Analysis", was withdrawn. In addition, there were 2 specially invited lectures of analytical interest by H. Glubrecht (IAEA): "The General and Special Programmes of IAEA in Activation Analysis" and E. Roth (France): "The Discovery and Study of the Nuclear Reactor in OKLO." A half-day visit to the research reactor facilities at the Institut für Radiochemie at Garching and the Gesellschaft für Strahlen- und Umweltforschung at Neuherberg was also arranged during the Conference.

The central theme of this Conference was in the area of applications. In order to maximize information exchange among participants, the range of applications was limited to reactions involving the nucleus. Within these confines, most of the contributed papers dealt with the widely practiced neutron activation (n,γ) techniques. In general, neutron activation analysis (NAA) is especially suited for determining elements which occur in trace amounts in nature. This feature is principally due to the fact that the light elements, which are abundant in nature, are either poorly activated or give rise to short-lived nuclides only. At present, the special attraction of NAA is the capability of rapid, non-destructive multi-element determinations.

This report will briefly highlight some of the more important and unique contributions in each of the sessions. The number of papers in each section is given in order to indicate the selection committee's emphasis and the present areas of emphasis in activation analysis.

a) Fundamental Contributions and Technical Development (16 papers): Recent studies of the analytical use of prompt γ rays induced by α bombardment were described. This method has the advantages that the number of different γ-ray energies from nuclear reactions is small (resulting in a simplified spectrum) and that the γ rays from nuclear reactions with

light elements (e.g., C, N, O, F, Na, Si, Al) give characteristic peaks in relatively under-populated regions of the spectrum. Another paper examined the opportunities for expanding 14-MeV NAA using 5×10^{12} to 5×10^{13} n/s generators. Increasing the neutron energy and flux to these levels permits the range of this method to be extended to sensitive, non-destructive determinations of B, S, As, Nb, Pd, Sn, Lu, Ta, Ir, Pt, Au, Hg, and Pb. Trace element analysis using NAA followed by high-resolution x-ray spectrometry was also described. In this method, interference from strong β emitters such as Na, K, Cl and P is nearly eliminated by magnetic deflection ($\sim$4-kG).

b) Biological and Biomedical Applications (30 papers): There were several research papers on *in vivo* NAA of human patients to determine such parameters as total body N, Na, Cl, Ca and P. These determinations require very strictly controlled irradiation of the subject and the most efficient counting geometry. Micromapping of lithium in rat brains and uptake studies were examined by the nuclear track technique. Lithium, which has high therapeutic specificity for manic-depressive psychosis and depression, is analyzed by counting the alpha tracks produced in cellulose nitrate from the thermal neutron reaction: $^{6}Li\ (n,\alpha)\ ^{3}H$.

c) Environmental and Ecological Applications (28 papers): Nearly one-third of the papers in this section were concerned with activation analysis applied to atmospheric particulates. The NAA method is particularly suited to terrestrially-derived aerosols rather than oceanic aerosols, since Na background is much lower in the former case. Photon activation enables diagnostic marine aerosol components such as fluorine to be determined by eliminating background ^{24}Na interference which would occur by neutron activation. Most of these aerosol researchers are in the rather unusual position of having an excess of analytical data (e.g., 40 or more elemental concentrations per sample using 2 irradiations and 4 counting intervals). For classification purposes, several of these elements provide redundant information and therefore in future, the analytical procedure and data reduction should select only key elements which will permit reliable interpretation of aerosol sources, transport mechanisms and atmospheric reactions.

d) Materials Sciences and Industrial Applications (28 papers): Emphasis in this session was on activation analysis of metallic samples, semiconductors and their films, particularly in quality control applications. A nuclear microprobe method was described for the simultaneous determination of Si and N distribution throughout metal specimens. In the area of process monitoring, on-line activation by ^{252}Cf has been used to determine F and Ca in fluorspar tailings.

Although natural diamonds are renowned as one of nature's purest minerals, the majority of them (including gem-quality stones) contain several impurities. To date, nuclear analysis has been used to quantify non-destructively 53 of the 58 elements other than carbon that are present in diamonds. Knowledge of trace impurities aids in assessing physical properties of diamonds and their origin and genesis.

e) Applications in Geo- and Cosmo-Sciences (19 papers): In these fields, a primary attraction of NAA is the sensitivity of the method toward rare earth elements (REE). REE patterns in meteorites, lunar and terrestrial samples are extremely useful in geochemically characterizing rock types. Analytical precision can be easily enhanced by radiochemical group separations of REE (as hydroxides and fluorides), followed by the usual Ge(Li) detection of γ radiation.

One author described fission/α-particle track analysis, a new geological technique for the measurement of U, Th and isotopic disequilibrium. While the precision of this method is not equal to that of the more detailed α-spectrometric method, its accuracy is likely to be greater. In addition, this author states (tongue-in-cheek, I hope) that "the technique is so simple that it can be confidently relegated to a lab technician, or even to a graduate student."

f) Applications in Archeology, Art and Forensic Sciences (13 papers): Papers in this session dealt with detection of forgeries, determining origin of drugs (e.g., opium and cannabis), analysis of bullet lead and confirming the archeological provenance of potsherds and coins by standard NAA techniques. Several different multivariate statistical techniques were also presented for the interpretation of

the elemental concentration data. One interesting paper examined trace element concentrations in ancient glasses to detect correlations bearing upon their long-term behavior toward corrosion and devitrification. These glass stability studies may be important since vitrification is one of the most promising preparative procedures for the long-term storage of radioactive waste.

g) Accuracy and Precision (11 papers): Topics in this session included radial efficiency gradients in Ge(Li) γ detectors, quantitative evaluation of interference in photon activation analysis, and the examination of computer programs and peak area computation methods used in analyzing γ-ray spectra. There is an evaluation in progress which entails sending test spectra to several activation analysts who then use their computer programs to find the γ peaks and to calculate their positions and areas. The test spectra contained about 80 γ lines with different levels of difficulty for finding peaks and their areas: interference-free intense peaks, weak peaks and overlapping peaks. Preliminary results of this intercomparison show that with intense peaks the data are consistently in better agreement than with weak peaks and that with overlapping peaks many of the programs fail. Since the number of different γ-ray spectra computer programs nearly equals the number of laboratories using activation analysis, such an intercomparison should be as routine as the accepted procedure of using US Geological Survey rock standards or NBS Reference Materials.

h) Sampling and Homogeneity Control (6 papers): Low temperature ashing (LTA), a process which removes organic carbon from biological samples and organic matter, has several analytical advantages when used as the first step in activation analysis. For example, LTA usually results in a substantial reduction of sample volume permitting a reduction in electron acceleration or neutron generator irradiation time. However, a systematic study of LTA applied to NBS Standard Reference Materials--coal, beef liver and orchard leaves--showed some losses of the following elements from the original matrices: Hg, Os, Cl, Br, I, Cr, Ga, As, Se and Rb.

i) Standard Materials (4 papers): Activation spectra from multi-element standards such as natural rocks and minerals are often more complex than desired for practical use. A paper was presented which described in detail a convenient method for introducing desired trace elements homogeneously into a silica matrix. Another contribution stressed the importance of careful handling and surface treatment of non-ferrous metals to be certified for O, N and C content.

j) Comparisons with other Analytical Methods (6 papers): Although the ramifications of the session title were not discussed, this topic is nonetheless crucial to the future of activation analysis. Ultimately, the position of activation analysis as compared to other analytical methods such as atomic absorption spectrophotometry or x-ray fluorescence will depend on the precision and accuracy of the results and also strongly on economic aspects. The results in the papers presented at this Conference are a testimony to the analytical benefits of activation analysis. However, all activation analysis techniques do require relatively expensive instrumentation, availability of sufficiently energized radiation and personnel experienced in handling radioactive substances. In most cases, the method is not amenable to "analyses-on-demand." As was intimated countless times at the Conference, the power to analyze non-destructively well over 40 elements per sample with high reliability is perhaps the most convincing argument for activation analysis (principally NAA). Refinements in computerized data reduction, reduction of manual administrative procedures, and enhanced flexibility of irradiation energies are some areas which must be addressed if activation analysis is to remain competitive with other analytical techniques and survive in the future.

In summary, "Modern Trends '76" was of great scientific value to most of the Conference participants. There was ample opportunity to establish or renew contacts among the activation analysts from all parts of the globe. Cultural activities in Munich and the Bavarian Gemütlichkeit also contributed to the overall success of this meeting. The Chairman of the Organizing Committee, Prof. Franz Lux and his associates are to be congratulated for their accomplishments. (F.K. Lepple, NRL, Washington, DC)

EDUCATION

A NEW TREND IN FRENCH UNIVERSITIES

Among Frenchmen, their universities have acquired the unenviable reputation of training for unemployment. This is due in part to the difficulties experienced by some graduates, particularly in the humanities, in acquiring a job after graduation. This malaise has been described in a previous note (ESN 30-5:211). Engineers, particularly those trained in France's Grandes Ecoles (see ESN 30-8:360, and a forthcoming ONRL report on that subject), are having a much easier time locating a decent job, and until quite recently the French university system did not train engineers.

In 1972, the "Université de Technologie de Compiègne" (UTC) was created to fill the gap between the university system and the engineering Ecoles. It is France's first attempt to find a third alternative in her system of higher education. This alternative is directly inspired by US universities, and more particularly the institutes of technology such as MIT and Caltech. (UTC's university catalog bears a remarkable resemblance to MIT's course catalog). UTC's development and output are being closely followed and evaluated. If successful, one can expect a number of similar universities to crop up.

The UTC is a happy mix of the conventional French University system and the Grandes Ecoles. As in the latter, entrance is not automatic after one obtains a Baccaleaureat. Instead, candidates' records are examined by a committee and some of the candidates may then be interviewed. This selection system is reminiscent of the "Instituts Nationaux de Sciences Appliquées" (INSA) (see ONRL report "France's Grandes Ecoles"). The number of candidates admitted is about one half the number of applicants. This is still fairly large when compared with a similar ratio for the Grandes Ecoles (about 1/10). This is because UTC is still a very young university and its existence is not yet well known among the French university student body. It also explains the active public relations job that the administration of UTC is doing, using the media to let students and the general public know of its existence.

After being admitted, the candidate takes a basic set of courses with very little choice for the first 2 years. This phase, called the first cycle, is common to all branches of engineering. At the end of that cycle, the student selects his choice from among: chemical, mechanical and biological engineering, each of these being further subdivided into a number of specialties. It is also at the end of that first cycle that UTC admits new students who have spent 2 or 3 years preparing for the Grandes Ecoles' "concours" (entrance examinations) and have failed these exams. The second cycle consists of 3 years in the selected branch of engineering. At least one of these years is spent working in industry acquiring practical experience. At the end of the second cycle the student receives his engineering diploma.

Several bilateral exchange agreements have been signed with foreign universities: The University of Southampton (acoustic, mechanical engineering), the University of Pennsylvania in Philadelphia (all branches of engineering), Darmstadt, FRG and Göteborg, Sweden. Already 12 students have spent a year at the University of Pennsylvania. A student of engineering thus has the possibility of spending a year abroad while still receiving credit for that year.

Unlike the conventional university system, UTC does not grant Masters' degrees or "Licenses"; but like that system it offers the opportunity for a student to continue his studies and obtain a "Third Cycle" Doctorate (a shade easier than a PhD). More advanced studies leading to such a Doctorate are offered in 6 disciplines: biomechanics, control systems, chemical engineering, acoustics, failure of structures and mechanical engineering. There is a Department of Applied Mathematics which is a service department and offers only the Third Cycle Doctorate. UTC is on the semester system and receives entering students in the fall and during the winter. This latter admission date seems to be popular with students who have just completed their military service, those who have changed their minds

and decided in favor of the UTC, and finally those who come from the Southern Hemisphere.

Unlike other universities, UTC has close ties with industrialists of the surrounding region. These people sit on governing boards, provide the industrial training and, more importantly, provide positions for new graduates. As seems to be a new trend in France, the industrialists have a direct input to the engineering subjects offered (see ESN 30-5:211), i.e., they let it be known whether an engineering area is on the rise or decline, and thus they play a part in deciding how many candidates may be enrolled in a given discipline. Another feature peculiar to UTC is the composition of its faculty. Two-thirds are professional civil servants who were trained as university professors (graduates of the Ecole Normale Supérieure), and the remaining third are researchers and professional engineers who are hired on 3-5 year contracts. Such an arrangement provides flexibility as far as salary goes and enables capable young French scientists who have obtained, say, their engineering diploma in France and their PhD in the US or the UK to be on the faculty. Otherwise, without additional French diplomas, these people would find it difficult to become faculty members in the conventional university system. For the most part this young, US-trained faculty is quite enthusiastic about US teaching methods and is instrumental in transplanting some of these methods to UTC.

UTC has also an active program of on-going education for businessmen or industrial people who are willing to spend a day, a week or six months at the University as part of the learning process. Hospitals in Compiègne, Amiens and some in Paris have a close connection with the Biomedical Engineering Department. The Institute of Management and Information and the Town Planning Institute have also been created. Research, as in the Grandes Ecoles, relies heavily on industrial contracts. A new research building which will house most of the University laboratories is being built at Royallieu, some 2 km from Compiègne.

Universities of this type are needed in France for they provide a meaningful alternative between the Grandes Ecoles, which are too rigorous and selective, and the conventional university system, which lacks selectivity and does not offer engineering programs.
(A. Barcilon)

ENGINEERING

PROGRESS REPORT ON FLUIDYNE

In ESN 28-11:420 and ONRL Report R-14-74, H.G. Elrod described the Fluidyne concept and provided a contribution to its theory of operation. The Fluidyne is basically a heat engine in which a confined volume of gas is alternately displaced between heat input and rejection stages by means of an oscillating liquid column. By suitably coupling the oscillatory motion to an output device, it has been demonstrated that Fluidyne can provide useful work. The engine (or pump) has no moving solid parts in its fundamental form, and it is self-starting upon the application of a temperature difference which can be generated by low-grade heat sources such as hot water, industrial waste heat, or direct or collected solar power. More detailed descriptions are available from the references given above and from the article titled: "And Yet it Moves," in the August 29, 1974 issue of *New Scientist*, by Fluidyne inventor Dr. Colin West. My purpose here is to transmit the current status of the program at the Atomic Energy Research Establishment (AERE) in Harwell, where I recently visited West in his laboratory in the Electronics and Applied Physics Division.

West's current research objectives are centered about the task of scaling-up the Fluidyne both in output and efficiency. This has required analytical models that extend earlier small-disturbance treatments (such as that of Elrod) to include the effects of large amplitude motions. West's current analysis, which he did not describe in detail but will soon be published in an AERE report, includes such important but previously neglected factors as viscous losses and differences in gas pressure between the hot and cold sides.

The development work at AERE has been directed towards pumping systems. Ordinary water is still the working liquid. Others have been considered but because most liquids with low vapor pressure (which is desirable in order to maintain the gas/liquid interfaces) tend to have undesirably high viscosities. No doubt, water is not the optimum liquid, but West believes that this is not a crucial factor in overall Fluidyne performance. Considerable progress has been made in improving Fluidyne pumping efficiencies--these have been increased from fractional percentages to "several percent." (At AERE, Fluidyne has advanced to the stage of commercial exploitation, so exact performance figures are not freely given.) Pumps for irrigation have been developed and operated which give flow capacities of about 1000 gal/hr and will operate at temperature differences as small as 25 C.

Metal Box Overseas Ltd. and AERE have entered into a joint agreement to develop Fluidyne for use as a simple irrigation pump in arid areas. For this purpose a senior member of the MB engineering staff, Mr. Ram Pandey, has come from India to work with West. A prototype system has been built, and the program is apparently proceeding without difficulty. Interestingly enough, in India the machine will operate on heat provided by burning indigenous coal which is about as "available" as solar power when the technologies of energy collection are considered. The central problem with solar power, according to West, is obtaining a proper balance between efficiency and cost of solar collectors--a balance that is consistent with the design features (low technology, low cost, simplicity) of Fluidyne. These are matters that are currently being explored in the study that is aimed at determining the feasibility of solar-powered Fluidyne pumps for use in Egypt.

West told me that since the not-so-distant early days of Fluidyne he has had thousands of enquiries from interested parties throughout the world. It is certainly a fascinating concept, and one which might well make use of "free" energy and thereby have running costs that are sufficiently low to offset its low efficiency. (R.H. Nunn)

GETTING DOWN TO BUSINESS IN HEAT TRANSFER RESEARCH

Not too long ago, perhaps as recent as the 1940-1950 time period, the practical nature of engineering and the elegant indifference to application associated with the word "research" were such that "engineering" research" was seen by many as a self-contradictory term. In the prosperous '50s and '60s, however, there was Sputnik and with it an enormous awakening of public concern and admiration for things scientific. The Bachelor's degree became a mere learner's permit for engineers, the luster of an advanced education attracted many engineers into research-oriented academic programs, and the PhD scientist-engineer became a not only prestigious but profitable job description. Sets of nonlinear coupled partial differential equations replaced cams, gears, and pulleys as the things that intrigued young engineers.

In many cases engineering research projects were begun with little concern--either on the part of the engineer or the sponsor--for the ultimate payoff; there was plenty of money to support the solution of potential problems and the general upgrading of the personal and institutional talents involved. In the '70s, though, we have seen much of this technological squandermania come under severe scrutiny and sometimes to a painfully screeching halt. There are few today who doubt that research in engineering should be product-oriented. The problem, simply stated, is how to redirect engineering efforts towards the practical needs of society while maintaining and even improving the analytical skills involved.

The concern is certainly not restricted to the UK, but here events seem to have conspired to bring these issues to an emergency level. This article describes two activities, both involved mainly with heat transfer, that have been in some measure successful in conducting research, solving problems, and employing advanced methods in a cost-effective fashion. The first is the Heat Transfer and Fluid Flow Service (HTFS) which operates under an Atomic Energy Research Establishment (AERE) umbrella at Harwell and is also affiliated with the National Engineering

Laboratory (NEL) near Glasgow. I shall go on to describe Concentration, Heat, and Momentum Limited (CHAM) which is a privately-owned firm with headquarters in the London Suburb of New Malden, Surrey.

HTFS. The AERE has experienced a technology deflation that is in many respects similar to and connected with events in the US aerospace industry. Their answer has been to diversify into alternative fields that have a need for their in-house expertise, and in 1968 the HTFS was established as one of their endeavors "outside the nuclear power programme." Today activities such as these contribute over 40% of the total income to the UK Atomic Energy Authority.

The HTFS employs about 20 full-time professionals with an £800,000 annual budget, about half of which is contributed by sponsors. These number about 130 from industrial firms, largely petrochemical, around the world. The sponsors' dues range from £1500 to £3000 annually which qualifies them for full access to the results of a relatively large research program including design methods, computer programs, and technical advice and information. The sponsor investment is approximately matched by the UK government, a commitment that has recently been renewed for 3 years even in the face of intense pressure on government spending. A significant feature of the HTFS operation, which benefits the sponsors as well as the HTFS, is a system of 7 review panels composed of sponsor members and chaired by HTFS personnel. These panels essentially dictate the direction of HTFS research efforts and thereby insure customer benefit and research relevance.

The HTFS research team is divided into 7 main groups corresponding to the purviews of the review panels: Condensation, Air Cooling, Boiling and Two-Phase Flow, Cryogenics, Radiative Heat Transfer, Physical Properties, and Single-Phase Flow. In each of these groups the activities appear to be mainly experimental, and the research laboratories at Harwell and NEL show an enviable array of modern equipment and instrumentation for heat-transfer research. In addition there are several prototype process-plant systems available which are employed to bring the experimental conditions one step closer to actual plant operations.

The main products of the HTFS, in terms of what is delivered to the sponsors, are design reports. These invariably include computer programs with methods and data that reflect the latest research results. Examples of current experimental programs include a comprehensive investigation of condensation within vertical, horizontal, and inclined tubes, with and without noncondensible gases; the evaluation of plate/fin heat exchangers for the condensation of liquid nitrogen--this investigation has also served to identify the pressure and flow limits associated with phase-change induced instabilities; and the use of laser velocimetry to determine flow speeds and directions within combustion chambers.

CHAM. Both HTFS and CHAM are highly computer-oriented. But whereas HTFS uses the computer to determine system ratings and provide design specifications based upon correlations of experimental results, the CHAM operation is closer to the physical detail of fluid behavior and, perhaps inevitably, a step displaced from practical application. Even so, the programs that CHAM provides are in response to user requirements, and presumably lead, through the expertise of user engineers, to industrial products.

The origins of CHAM are to be found in the Department of Mechanical Engineering at Imperial College in London where, under the direction of Prof. D.B. Spalding, there was an early recognition of the power of the digital computer in predicting the behavior of complex fluid flows. A feature of the IC operation has been an attention to engineering applications, and in 1969 a group was set up to facilitate the flow of problems and solutions (and funds) between industry and the Imperial College researchers. Originally the group operated in a highly selective way as a sort of business front for channeling sponsor funds. About 3 years ago, however, the operation had grown to the point that full-time management was required, and CHAM was formed with Mr. J.E. Smith as the Commercial Director. Spalding, as Managing Director, retains his substantial influence on the technical quality and style of the company. CHAM has no official ties with Imperial College,

although there is a logical and intentional communion between the two organizations; in fact, a proportion of CHAM's profits are made available to support research at Imperial. From a full-time staff of 2 in 1974, CHAM has grown to a professional staff of about 15 with several additional part-time employees.

There are 5 groups at CHAM: Aerospace, Combustion, Nuclear, Processing, and Turbomachinery. Without exception, the products of these groups are computer programs to predict the behavior of complex flow situations. These include: rocket exhaust plumes and base heating, supersonic combustion, flames in zero-g environments, pollutant spreading, exploding gas bubbles (reactor accidents), electromagnetic liquid metal flows, interaction of blast waves with missiles, and secondary flows in radial compressors. Many of these problems are too complex to be treated in complete numerical detail, especially since the CHAM (and Imperial College) approach does not sidestep or "assume away" the effects of turbulence. The emphasis is on "plausible" solutions--those which provide information that is sufficiently accurate and detailed for engineering design purposes. A key to this approach is the numerical exploitation of some judgements concerning the behavior of the flows so that computer time and storage is not wasted in the calculation of motions and forces that can be legitimately ignored. The upshot of these judgements often is a class of flows that Spalding terms "partially parabolic."

In the most general cases, the conditions at a subsonic point in a steady flow field can be influenced by convection (transport due to mean motion); conduction and diffusion (transport by molecular or turbulent fluxes); and pressure (adjustment through molecular signal transmission). In such cases the governing equations are elliptic and, from the numerical point of view, each dependent variable must be stored in a 3-dimensional array because of the possibility that adjustments at any point in the field may cause "numerical nervousness" at all other points. In many practical problems, however, the Reynolds numbers are high in a dominant direction (the direction in which convective effects will be important relative to those of diffusion), and the presence of significant flow deflections due to boundaries gives rise to large pressure influences in the upstream direction.

For flows in which there are no reversals these conditions allow a streamwise marching technique in which only the pressure is stored in an n-dimensional array and all other variables (mean and fluctuating velocity components, temperatures, concentrations, etc.) are stored in (n-1)-dimensional arrays, where n is the dimension of the flow. The saving in storage is significant. For arrays with an equal number of points, p, in each dimension, the number of storage points, s, for m variables in an elliptic problem is equal to mp^n. For a partially-parabolic problem the requirement is: $s' = p^n + (m-1)p^{n-1}$ and the relative reduction in storage, Δ, is equal to $(s-s')/s$ or $[(m-1)/m]\,[(p-1)/p]$. Thus, for example, if $m = 7$ (pressure, temperature, and 5 velocities, say) and $p = 15$ then $\Delta = 0.8$, an 80% saving of storage. The partially-parabolic approach is more completely described in Pratap and Spalding, "Fluid Flow and Heat Transfer in Three-Dimensional Duct Flows," *Int. J. Heat Mass Transfer* 19, 1183-88 (1976).

The operations at the HTFS and at CHAM are quite different in their emphasis: an oversimplified view would describe these as experimental and numerical, respectively. They are similar, however, in that both groups are keen to apply their talents to actual problems. This desire transcends mere financial lust (although there is this as well), and seems to me to be leading to some rather elegant engineering in practice. In addition, both groups appear to be able to maintain a level of less-directed and perhaps more-creative research under their internal funding policies; CHAM, in particular, with their close ties to university savants and "staves" (student-slaves). I am not aware of the extent to which the two organizations cooperate, although I suspect this is minimal. Such a blissful union of theory and experiment might be worth an unholy alliance between government, business, and academia. (R.H. Nunn)

GENERAL

INSTITUTE OF ACOUSTICS (UK) AND ITS AUTUMN CONFERENCE SEPTEMBER 1976

The Institute of Acoustics was formed as recently as 1974 from an Acoustics Group of the Institute of Physics and the British Acoustical Society, and was the last in a number of changes in the organization of acoustics in the UK in recent years. The Institute's role in undertaking arrangements for the 8th International Congress of Acoustics held in London that year was of considerable value in launching it on its way. Subsequently, it has made substantial progress in membership, the formation of specialized groups, and in the organization of its meetings and publications. With a membership of more than 1000, professional grades of Fellow and Member have recently been created with requirements similar to those of other professional organizations in the UK in order to establish the status of the profession and to integrate the acoustician into the national professional structure. Specialized groups within the Institute now include Underwater Acoustics, Speech, Aerodynamic Noise, Industrial Noise, Musical Acoustics, Building Acoustics, and Physical Acoustics. These undertake the organization of meetings supplementing the Institute's conferences. Publications include a quarterly bulletin usefully summarizing acoustic activities in the UK and elsewhere, and there are prospects both of an annual publication of principal lectures and addresses and of the issue of conference proceedings.

The Institute now holds 2 conferences annually in the Spring and Autumn. Held in different venues, each conference covers a limited number of topics. The Spring conference at the Liverpool Polytechnic, April '76, encompassed sessions on Loudness Evaluation, Ultrasonics, and Noise in Buildings, the latter with a special session of Open-Plan Acoustics. The Autumn Conference, held at Heriot-Watt University on its Riccarton Campus near Edinburgh on 2 and 3 Sept., had sessions on Integrated Environmental Design, Musical Acoustics and Speech Communication. Unfortunately this structuring of conferences with concurrent sessions in a relatively small society, together with additional specialized meetings organized by its professional groups, tends to fractionate the Institute's membership and does not encourage cross feed between the various specialized areas. It was noticeable, in fact, at the Autumn Conference with an attendance of about 90 (almost all from the UK) and only about half that at the Spring Conference, that there was little movement of attendees from one to another of the concurrent sessions.

Integrated Environmental Design (IED)--Attendance at these sessions rarely exceeded 25, possibly because closely related topics of noise in buildings had been covered at the Spring Conference. The subject, however, appeared a timely one in view of its close relation to energy considerations. In total a dozen papers were presented ranging from general discussions of the IED concept and its application, to discussion of acoustic problems associated with individual components in building structures, services and treatments--windows, ceiling panels, ducts, etc. The session opened with an excellent, if brief, appraisal of the role of acoustics in IED by P.T. Lewis (Welsh School of Architecture, University of Wales). It concluded with a review with accompanying aural demonstrations of work being done at the University of Salford by Martin West on the acoustic modeling of an open-plan office which requires simulation of background speech in a manner suitable to its importance to local speech privacy.

Historically, solar overheating of buildings with extensive glass coverage and the associated high cost of cooling in summer (and heating in winter) were probably key elements in the development of the IED concept in the UK. From this experience 2 diametrically opposite views developed on how to solve building environmental problems--heating, lighting, ventilation and noise. One hinged on natural methods, looking back to the success achieved in Georgian buildings; the other advocated the apparent advantages of the completely artifical (and presumably controllable) environment. Cost advantages associated with deeper-plan structures with large floor areas, as compared with the

narrow structures necessary for daylight lighting were probably the deciding factor in the movement to the deeper structures which require an artificial environment. The large floor areas of the deeper-plan also brought the possibilities and flexibility inherent to open-plan spaces. With this trend the IED concept appeared on the scene. Essentially IED recognizes that individual environmental parameters cannot be treated separately and that building design must consider the human requirements for the space provided and the interactions between the structural design and the various services needed to meet those requirements. IED may well be equated with Artificial Environment Design as far as large buildings and open-plan structures are concerned--the principal topic addressed.

The various building case-studies presented ranged from complete IED design and construction, through application of IED to existing structures and open-plan spaces, to examination of users' environmental complaints and their correction. Together, they repeatedly emphasized the complex nature of the interactions involved between the structural design and layout, the services, the internal environmental requirements, the location, orientation and external environment of the building itself, the intended usage of the space available, and perhaps, above all, the cost factors. For example, lighting which must meet acceptable standards substantially affects the thermal environment, increasing the air-conditioning and ventilating load on the plant which must meet peakload summer requirements. Larger plant may be required with increased cost, potential siting difficulties and noise problems.

Numerous participants stressed the importance of the Design Team and the need for all environmental factors and services to be represented on it, but there was a plea that membership carried a responsibility for decision and for realistic first-order approximations in the early design. At least one speaker emphasized the desirability of the client's being represented directly on the team in order to provide requirement/cost interaction and appreciation.

The papers and discussion left no doubt as to the great importance of the ceiling structure in the open-plan, for it is the usual vehicle for the environmental related services, such as lighting and air conditioning, and for much of the acoustic treatment. These must be accommodated in the structure with concurrent recognition that the ceiling is perhaps the primary contributor to the aesthetic environment in the open plan. Its more difficult acoustic problems include the fact that it provides flanking transmission over installed partitions.

For a group and speakers largely dedicated to IED and the artificial environment, it was reassuring to find fairly general recognition that some visibility of the window, however remote, is psychologically and aesthetically important to the occupant.

Even when considering the acoustic aspects alone, potentially conflicting requirements and solutions frequently arise, as for example in providing acceptable low background noise levels and speech privacy concurrently in the open plan. Promotion of background masking systems as a solution in this particular case brought forth a spirited discussion of their pros and cons, especially after a suggestion that they were too frequently used to correct possible errors in the acoustic design of treatments and barriers.

Despite the small attendance at the session, discussion was good. The consensus appeared to be that even with the rising cost of energy and the substantial cost of associated services, which are now of the same order as those of the main structure, the trend to deep-plan buildings and the artificial environment will persist. There can be little doubt that IED is here to stay, but one has the feeling that it will be a long time before it is not necessary to resort on occasion to "cut and try."
(A.W. Pryce)

PETER KAPITZA AND THE SHADE OF BERNAL AT THE ROYAL SOCIETY

It seems quite natural that Professor P.L. Kapitza should have been invited to give the Bernal Lecture at the Royal Society. Like the late Professor J.D. Bernal, Kapitza has combined a career of the utmost scientific distinction--his list of honorary degrees and medals reads like a catalog of the world's most august institutions--with a profound concern for society and the social duties of

the scientist. In Bernal's case, the scientific field was crystallography in the broadest sense; the inner brilliance of his work (with I. Fankuchen) on the structure of tobacco mosaic virus and its coacervates, of his celebrated article (with R.H. Fowler) on water, and of his speculations on the properties of some unusual polyhedra, establish him as one of the founders of molecular biophysics, a field in which the objects of study possess much less outward glitter than the crystals more conventionally accepted by crystallographers. Bernal's driving sense of social responsibility, expressed at length in his book *The Social Function of Science*, has been extended posthumously by an endowment which provided the lecture fund and made possible a triennial lecture on some aspect of the subject.

Kapitza, it will be recalled, spent several years at the Cavendish Laboratory during the Rutherford era. As a Royal Society Research Professor and Director of a Royal Society Laboratory, with a brilliant career in England firmly established, he caused quite a stir by returning to the USSR in 1935. Aside from intemperate opinions that the move amounted to a defection to communism, voluntary or coerced, there was fear that the loss of Kapitza's talents in magnetism and cryogenics (later extended to the study of high temperature plasmas) would be a serious blow to Western science. In fact, the brilliant career continued on its way with, at worst, a passing loss to the world, for over the years 1964-7 the *Collected Papers* were published in three volumes. About the fruits of Kapitza's socio-scientific activities I have little information, but his Bernal Lecture made an impression which I shall try to convey in a few paragraphs.

The lecture, entitled: "Scientific and social approaches for the solution of global problems", was given at the Royal Society's rooms on 7 October 1976 before a large and distinguished audience under the chairmanship of the President, Lord Todd, who welcomed the guest as one of the most senior surviving Fellows: Kapitza's FRS dates from 1929.

I suppose Kapitza might be described as an exponent of scientific humanism tinged with spirituality and puritanism. He recognizes that man's interference with nature through science and technology has led us close to catastrophe, but he sees the continued application of science as the only means of averting the eventual destruction of civilization. Religion, he says, offering many solutions, commits the same blunders over and over again; science recognizes that there can be only one solution to a given problem (as distinct, presumably, from technology which may offer procedural variants based on the same facts) and is therefore universal. Once a problem is solved by science, errors that preceded its solution are not repeated. Science therefore can lead us out of our predicament by correctly analyzing the situation and deriving solutions which will involve humanity as a whole. The Olympian detachment suggested by this point of view does not blind Kapitza to the fact that social acceptance is a serious obstacle and I gathered that he seeks scientific analyses of social structures based on the discoveries of Freud and Pavlov. However, the denizens of Olympus are not necessarily proficient in English, and there was good reason for the speaker's touching invitation to the audience to divine what he was thinking rather than to pay too much attention to what he was actually saying.

He identified the 4 most important global problems as those arising from population growth, depletion of energy sources, exhaustion of minerals and environmental pollution. In offering his solutions within the compass of an hour, Kapitza could hardly have been expected to provide proofs. Confronted, then, with an argument from which the underlying data were inevitably missing, one can only accord them the courtesy that their author commands as a scientist, and display qualified acquiescence, if you will, in the face of authority.

Well, it is easy to accept Kapitza's proposition that a continued 30-year doubling period of world population will multiply our difficulties. Hunger and existing social structures make for poor quality and we may well be heading for a Brave New World peopled by a few alphas of intellect and many gammas of increasingly simian proclivity. Clearly constraints on growth are necessary. These, Kapitza thought, should be applied by the UN Committee on Human Rights to Article 16 of its Declaration, which now avers freedom to reproduce at will from 16 years of age onwards. There

is not much science in the solution offered: a balance between legislation and voluntary suppression of impulses, increased respect for mental and spiritual values, combined with an unconcern for health--this last, presumably, because a species that can survive in such vast numbers ought not to be worrying too much about its medical history.

The energy problem, said Kapitza, is much simpler. The energy requirement per capita in the US is at a rate of 10 kW of which only about 1% can be provided by muscular work. Of these 10 kW, 9 are furnished by combustion of materials which will soon be exhausted. New natural sources offer little hope. Solar energy on a large scale is prohibitively expensive, requiring an area of 10 km^2 for 1 GW at a cost of about 2.10^{11} roubles (order of magnitude $\$10^{11}$), and cannot be easily stored. While earth-based nuclear energy in some form will provide the ultimate solution, he believes that fission processes are unacceptably hazardous. There is no known safe container for active residues, while conventional and breeder reactors pose a constant threat of mishaps which could be worse than the Hiroshima bomb. Furthermore, no world organization exists with the authority to regulate the spread of plutonium. Kapitza puts his money squarely on fusion in a hydrogen-isotope plasma which cannot be used for bomb manufacture and which leaves no dangerous residues. The temperature needed is 10^8 C, attainable in principle with a superconducting solenoid costing about $\$2.10^{11}$. The price is so high that, private investment being unobtainable, effort on a national or international scale is essential. There is no doubt in Kapitza's mind that this will eventually materialize.

Concerning depletion of mineral resources, Kapitza sees no immediate crisis and no insuperable difficulties. Like everybody else he favors recycling of phosphorus while, evincing no shudder of distaste, he expresses enthusiasm for synthetic food. Pollution, too, seems from his lofty vantage point to present no scientific difficulty in a closed cyclic system, save perhaps the long term danger of climatic change. The heat balance is delicate and shifts of ±10 C would be of major importance. Reliable calculations are difficult because the mean temperature of the earth is unknown and no method exists for measuring it.

Here the lecturer, too, completed a cycle bringing us back to his central theme: there are scientifically soluble global problems which cannot, in fact, be implemented unless the scientists deepen their involvement in the concerns of society. Back to Bernal, who "started it all". (J.B. Bateman)

MATERIALS SCIENCE

FIFTEENTH INTERNATIONAL CONFERENCE ON ACOUSTICS-ULTRASONICS IN PRAGUE

The International Conferences on Acoustics are called once or twice a year in cooperation with the Czechoslovak Academy of Sciences, with the specific topic of the meeting changing from year to year so that the Ultrasonics Conference takes place only about every third or fourth year.

More than half the scheduled papers in this ultrasonics meeting, 5-9 July 1976, were by East-European authors, the remainder being by representatives of about a dozen non-Communist countries. The papers were presented in 4 simultaneous sessions (physics, measurements and control, industrial applications, and medical ultrasonics). Some were given in English, others in Czech, German, French, or Russian with simultaneous translation (very, very good) available.

It was noticed that Soviet ultrasonics continues to be strong in theoretical and basic experimental research, while scientists in Czechoslovakia, Poland, the German Democratic Republic and other socialist countries are more inclined to be concerned with applications and technological aspects. Here it was obvious--this also came through in discussions I had with Eastern scientists--that technology in these countries is much behind that of the West, particularly the US. A great deal of effort appears to be going into the construction of electronic

and other auxiliary devices--things which are readily available for a few dollars in the US.

Judging from the attendance one was led to suspect that the DDR and Poland are concentrating on ultrasonic techniques in the biological and medical field; Czechoslovakia seems to tend towards technological topics such as nondestructive testing of heavy machinery, industrial goods, building materials (cement, roads), flow and liquid level meters.

The papers abstracted in the Conference Proceedings reflect the same trend. The section on basic research lists 14 contributions by Soviet authors; 11 of these papers deal with various aspects of relaxation processes and absorption or with fundamental questions related to molecular acoustics. On the other hand, only 2 papers listed in the 33-paper section on applications are authored by Soviet acousticians.

Noticeably absent were papers on ultrasonics in communication and signal processing. A treatment of these topics would perhaps be closely tied to the availability of somewhat advanced apparatus--and the East does not seem to be heavily endowed with computers. The few pocket calculators in evidence were made in Japan.

Attendance at the Conference was generally good despite the fact that an inordinately large number of delegates from Eastern Europe failed to appear. This caused massive on-the-spot rearrangements of the program and allowed ample time for frank and probing discussions. The researchers from socialist countries seemed highly motivated, knowledgeable, and fairly well up-to-date. They seemed genuinely interested in the papers given by their colleagues from the West and to welcome any contact with them. (W.G. Mayer, Dept. of Physics, Georgetown U., Wash Washington, D.C.)

ONRL REPORTS

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18TH POLISH SOLID MECHANICS CONFERENCE

The planning and organization for the technical aspects of the 18th Polish Solid Mechanics Conference, in Wisla-Jawornik from 7-14 September, were completed under the auspices of the Polish Academy of Sciences, Institute of Fundamental Technological Research. Professor Dr. Zenon Mros was the chairman of the organizing committee and Dr. Maria Arcisz served as secretary. The selected scientific papers were grouped into 26 categories. Two simultaneously scheduled sessions took place each half day in separate lecture rooms. In addition, there were 13 invited scholars each of whom presented hour-long lectures. Two invited lectures were delivered each day, except for the last day when only one was presented.

The technical planning and organization were satisfactory, although there were some language problems (about 20% of the talks were given in the Polish or Russian language), and there was very little in the way of advance program material. The accommodations and services, which were entrusted to "SPORTS-TOURIST," were regrettably very disagreeable. Participants from Western nations were required to pay higher fees than those attending from the East, and the variety of currency exchange procedures (including the black market) was confusing and often costly. Even after meeting the inflated costs levied by Sports-Tourist, the facilities, food and services were not up to this participant's expectation.

In spite of the Sports-Tourist "ordeal," the technical aspect and the interchanges with other participants was most pleasing. There were participants from some 19 countries as follows: the overwhelming majority (163) from Poland; 6-12 from the US, USSR, West Germany, and Italy; and a few each from a number of other European countries and from Greece, Turkey, India, and Australia. A list of participants' names and their addresses was not provided.

It was somewhat surprising to note a resurgence of interest in finite-difference methods. Highly significant contributions were presented by Dr. T. Liszka and by Dr. J. Orkisz (Politechnika Krakowska ul Warszauska 24, Instytut M-1). The procedures

described in their papers entitled "Application of Finite-Difference Method to Non-Linear Problems of Solid Mechanics" and "A Modified Finite-Difference Method with an Arbitrary Mesh in Problems of Mechanics" appeared to have great advantages over finite-element methods. The authors utilized an arbitrary and even irregular mesh which was generated automatically by digital computation. They were able to describe the boundary conditions on an arbitrary shaped boundary and make a local mesh congestion for increasing the accuracy in areas of high stress gradients, inhomogeneities, etc. At the same level of accuracy, and compared to finite-element methods, a set of equations with a smaller number of unknowns was obtained.

In another finite-difference application, numerical calculations were made using skewed elements on problems of plane stress. Algol programs were utilized resulting in significant savings in computer storage when compared to the finite-element method.

Several other numerical methods were presented in various papers, namely in studies of vibration, heat conduction, wave propagation, stability, elasticity, plates and shells, and biomechanics. One interesting approach presented by Drs. J. Brilla, S. Lichardus and A. Nemethy from Bratislava, Czechoslovakia, dealt with time-dependent problems by transform methods. In viscoelasticity, the distribution of displacements and internal forces varies in time and is not equal or proportional to the elastic case. The solution was, however, based on the associated elastic problem in the manner in which the Laplace transform was presented. The inverse transformation of the problem is very complicated but may be attained numerically. This leads to the collocation method, then the final solution in the form of Dirichlet series. These authors, from the Institute of Construction and Architecture, Slovak Academy of Sciences, defined generalized potential energy and generalized variational methods, and in the numerical solution, they utilized a variational finite-difference method. They claimed that this procedure may be successfully applied to structures made from linear viscoelastic materials with aging properties.

It appeared significant that at this conference there seemed to be a noticeable trend in the use of numerical methods which represent alternatives to the finite-element method. Discussions with participants pertaining to this observation indicated a growing concern about inaccuracies and errors which occur when finite-element methods are applied to certain problems. Furthermore, finite-element methods require large computer capacity and lengthy computer time in the studies of practical problems: many find these requirements too costly.

A great many of the talks were highly theoretical in nature, especially those contributed by Polish participants. One paper presented existence and uniqueness theorems for certain proposed generalized solutions in the linear theory of Cosserat elasticity. Another paper showed that by means of the Fourier integral transform, it was possible to reduce the dual integral equation in the coupled theory of continuum mechanics to a Fredholm integral of the II kind. A particularly interesting paper presented the continuum in 4-dimensional space-time according to the concepts of general relativity. Special equations of motion were presented in Eulerian coordinates. One author presented a method of analysis and inversion of non-linear constitutive rheological operators for cases of weak viscoelastic nonlinearities. Still another Polish author presented orthogonal projection methods to the solution of the dynamic boundary problem of magnet-thermoelasticity. A convergence theorem was also presented. Another theoretical paper was based on considerations of topological theory in "neoclassical" thermodynamics.

There were very few experimental papers and, of these, most dealt with the application of routine experimental techniques to specific problems. An exception involved a modification to the "hole drilling" method for analysis of residual stress. Except for the method of "caustics," no modern optical methods were presented. Informal discussions with Eastern European researchers indicated that it is still costly and difficult for their laboratories to obtain lasers and related optical facilities. In many cases, such facilities are being planned.

All in all, I felt that this Conference served as an important medium for information exchange. The talks

were generally well-presented and represented reports on high-quality research. (J. Der Hovanesian, Oakland U., Michigan)

EDINBURGH GALLIUM ARSENIDE SYMPOSIUM

Compound semiconductors such as gallium arsenide present a tantalizing area of research in electronic device technology. Their great potential, for example, in the realm of higher speed/frequency performance, relative to silicon, has gone unrealized in many areas because of materials and processing difficulties. The 1976 International Symposium on Gallium Arsenide and Related Compounds, held at the University of Edinburgh on 20-22 September, demonstrated that, in spite of real progress in materials, characterization and device processing, the total fulfillment of the promise remains some years distant. Nevertheless, much of the current work has its own fascination in furthering our understanding of an interesting class of material and as steps on the path towards a viable device technology. In this review of the 1976 Symposium, the three general areas cited above--materials preparation, characterization, and device processing and performance--will serve as a framework within which the reports of new research will be described. About 50 papers were presented; because of space limitations not all of these can be referred to specifically. The Proceedings of the Symposium will be published in the Institute of Physics Conference Series (No. 33A). Information can be obtained from: Mr. N. Haskins, The Institute of Physics Publishing Division, Techno House, Redcliffe Way, Bristol BX1 6NX, Great Britain.

Materials growth and related problems were discussed in numerous papers, with emphasis about equally divided between ternary alloys and binary compounds. In the first group, J.P. André *et al.* (Laboratoire d'Electronique et de Physique Appliquée, Limeil-Brevannes) presented a description of the use of the metal-alkyl hydride process as an alternative means of producing GaAs/GaAlAs heterostructures. A GaAs substrate is exposed to an atmosphere containing trimethyl gallium, trimethyl aluminum and arsine at 700 C. The relative amounts of Al in the vapor and in the deposited alloy films show a 1:1 correspondence, thus simplifying the task of obtaining the desired alloy composition. The best (undoped) n-type materials yielded values of (N_D-N_A) equal to $3\cdot10^{14}$ cm^{-3} and a mobility of 7900 $cm^2v^{-1}s^{-1}$ at 300 K. Zinc doping yielded p-type layers with (N_A-N_D) in the range 10^{16} to $5\cdot10^{19}$ cm^{-3}; at $5\cdot10^{18}$ cm^{-3} the mobility was 100 $cm^2v^{-1}s^{-1}$. Minority carrier diffusion length measurements showed that the material was of device quality, although no devices have yet been made.

The structure and defect properties of alloy films for heterostructure applications received much attention. A study of nucleation processes for the growth of an active layer on an underlying layer--$Ga_{0.9}Al_{0.1}As$ on $Ga_{0.65}Al_{0.35}As$--was described by M.B. Small *et al.* (IBM Watson, Yorktown Heights). The active layer must be very thin (300 Å or more) and have a planar interface with the substrate in order to achieve high efficiency operation. This necessitates a high uniform density of nucleation sites. Substrates very near (100) orientation exhibit growth on terraces. For orientation further from (100), meniscus lines left by previous solutions serve for nucleation. Research on crystal defects in 5-layer GaAs/GaAlAs LPE (liquid phase epitaxy) heterostructures was described by G.R. Woolhouse (same affiliation). These structures degrade rapidly when the defect density is too high. Optical and TEM (transmission electron microscopy) data showed that the defects are caused by inclusions incorporated during growth, and 4 distinct types of defect cluster were observed, each cluster having dislocations with Burgers vectors totalling zero. The identity of the included material could not be determined, although Auger spectroscopy typically reveals carbon particles incorporated into similar structures. In fact, carbon often seems to appear when high temperature processing is required, and its significance may not yet be fully appreciated. While it may not be in itself electrically active, it apparently produces structural effects which in turn affect other properties. Its source could be either the substrate bulk or surrounding materials and atmosphere. In addition there was discussion by

C. Schiller (Laboratoire d'Electronique et de Physique Appliquée, Limeil Brevannes) of the effect of unrelieved strains in graded pseudo-binary III-V heterostructures due to lattice mismatch. Misfit locations remove much of the strain; the remaining material is elastic.

On the subject of preparing binary materials, papers were presented on InP, GaSb, and GaP. Progress in LPE growth of InP has been achieved through the use of long melt and pre-epitaxial bakes (Wrick *et al.*, Cornell; Henry *et al.*, NRL). Mobilities at 77 K of about $4 \cdot 10^4$ $cm^2 v^{-1} s^{-1}$ were obtained, still well below the best values observed in samples grown by VPE (vapor phase epitaxy). A recent interesting technique is exposure of the substrate to a liquid melt of the metal constituent for a short time just prior to epitaxial growth. This treatment removes the oxide skin and has proved beneficial for both In and Ga compounds. It is thought that an oxide skin on the growing epitaxial layer itself might be responsible for limiting purity in the LPE InP by preventing volatilization of foreign atoms at elevated temperatures. Other work by Benz *et al.* (U. Stuttgart) on GaSb, both VPE and LPE, yielded minimum carrier densities (N_A-N_D) just below $2 \cdot 10^{16}$ cm^{-3}. Doping with Ge and Si was studied; these impurities act as acceptors with binding energies of 10.0 and 12.5 meV respectively, as determined by photoluminescence measurements at 2 K. Finally, solubility measurements were described by H. Beneking *et al.* (Technical U., Aachen) on the Sn-Ga-P-Si quaternary system, via the growth of GaP layers from a Sn-rich melt on Si substrates. It was observed that (111)-oriented Si yielded by far the best morphology of the layers.

A number of papers from the "Materials," "Deep Levels," and "Physics" sessions of the meeting might well be classified under the heading "Materials Characterization." These papers dealt with various methods such as photoluminescence, photocapacitance, ESR (electron spin resonance), charge transport, and optical scattering and absorption for the determination of materials properties. Techniques using optical excitation appear to be favored because of their high energy and spatial resolution capabilities and because, in some cases, they are contact-less. The use of photoluminescence (B.D. McCombe, NRL) is exemplified by a study of surface degradation of semi-insulating GaAs substrates which occurs during LPE growth. The growth cycle was simulated by heating a bare Cr-doped substrate to 740 C for 100 minutes. Photoluminescence spectra taken before and after this treatment were compared and the differences related to the accumulation of carbon atoms and As vacancies at the surface during annealing. Restoration of good surface characteristics was achieved by exposure to a Ga liquid melt.

An elegant application of photocapacitance spectroscopy to the study of deep traps in InP and GaAs was described by A.M. White *et al.* (Royal Signals and Radar Establishment, Great Malvern, UK). This technique is capable of detecting both majority and minority traps further than about 0.3 eV from either band edge in material containing fewer than 10^{16} carriers cm^{-3}. The relation of various defect species to growth conditions, heat treatments, and substrate characteristics was demonstrated. In addition to these and other applications of photo-excited luminescence and capacitance, two relatively simple optical characterization experiments were described. In one (M. Tajima and T. Iizuka, Electrotechnical Laboratory, Tokyo), light from a Xe source was focused on the polished face of a GaP crystal and the radiation scattered at 90° within the sample was observed in an optical microscope. Two distinct types of scattering pattern were found, which were related to impurity precipitates, either isolated or associated with dislocations. The latter gives rise to a line pattern; the former is characterized as a "cloud pattern" and occurs in regions which are relatively dislocation-free. In the second (K. Laithwaite *et al.*, U. Reading, UK), absorption in the spectral range 40-1000 cm^{-1} due to defects (Si_{Ga}, Si_{As}, B_{Ga}, B_{As}, C_{As}; i.e., Si on a Ga site, etc.) and local modes was observed in electron-irradiated (2 MeV) Si-doped GaAs.

Still another technique utilizing optical excitation is photo-sensitive ESR, in which the charge states of paramagnetic defect species can be altered via photon-induced charge exchange. The atomic configuration and site of a defect strongly affect its resonance characteristics and thus are capable of being determined.

Two papers utilizing this technique were presented, concerning Cr ions in semi-insulating GaAs (J.J. Krebs and G.H. Stauss, NRL) and anti-site defects in GaP (U. Kaufman and J. Schneider, Institut für angewandte Festkörperphysik, Freiburg). Finally, in the realm of charge transport measurements were papers concerned with the need for a 2-band model analysis for n-type GaAlAs (K. Kaneko *et al.*, Sony, Yokahama) and the incorporation of effects due to compensation and impurity fluctuations in the analysis of Shubnikov-de-Haas oscillations in GaAs (A. Raymond *et al.*, Centre d'Etudes d'Electronique des Solides, Montpellier).

Papers on device performance, processing, and reliability comprised the third segment of the Symposium. On the subject of GaAs FETs (field-effect transistors), the performance of 2 specific devices was reported. One (R.S. Butlin *et al.*, Plessey Co., Towcester, UK) is a narrow-band amplifier at 8 GHz with a 2.2-dB noise figure and 7-dB gain, which employs an n-active layer sandwiched between n+ contacting and high resistivity buffer layers. The other (B.S. Hewitt *et al.*, Bell Laboratories, Murray Hill), which also required a buffer layer for optimum performance, had a noise figure of 1.6 dB and associated gain of 11 dB at 6 GHz. Investigations into GaAs FET reliability by long-term and accelerated testing were described (D.A. Abbott and J. A. Turner, Plessey Co., Towcester, UK), the dominant failure mode being metal migration of the ohmic contacts. An activation energy of 1.1 eV was calculated from the data. The use of 0.2 MeV proton bombardment by J.D. Speight *et al.* (Post Office Research Center, Martlesham Heath, UK) to isolate microwave devices by inducing high resistivity regions in both n- and p-type GaAs, using doses well below the amorphetization range, and of cathodo-luminescence (S.M. Davidson and A.W. Vaidya, U. Manchester) to measure device operating temperatures with high spatial resolution, were discussed. Several papers also dealt with etches for specific applications and with annealing and the diffusion of impurities. P.D. Greene (Standard Telecommunication Laboratories, Harlow, UK) presented a description of preferential dissolution of n-GaAs in an aqueous Fe(III) solution under strong illumination--photochemical dissolution. The attack on adjacent p-type material is only 1 μm h^{-1} while the main attack on n-type is 20 μm h^{-1}. D.J. Stirland (Plessey Co., Towcester, UK) re-examined an A/B etchant, used by investigators for its ability to delineate dislocation lines and correlated the results with TEM studies. The "s-pits" usually seen were identified with precipitates near dislocations. B.J. Sealy *et al.* (U. Surrey, UK) implanted 2 x 10^{14} Sn ions per cm^2 at 300 keV and 200 C and deduced an activation energy for the subsequent annealing as 0.7 eV, compared with 1 eV previously found for Te and Se in GaAs. They also find 2 regions of damage--a shallow one predicted by standard ion-penetration theory and a deeper one which accounts for 1% of the electrical activity.

An area of current interest to both device and basic researchers is the attempt to produce device-quality MOS (metal-oxide-semiconductor) structures on GaAs using native oxides. A description of progress in assessing the effects of annealing and other processing steps on anodically-grown oxides was given by B. Weiss *et al.* (U. Newcastle upon Tyne, UK). FETs made with these oxides exhibit reasonable mobilities, typically 2000-3000 $cm^2v^{-1}s^{-1}$, but relatively low values of the transconductance. The gate voltage thus does not appear fully effective in opening a channel, implying a low electron density.

The final sessions of the Symposium dealt with subjects in opto-electronics, primarily LEDs (light-emitting diodes). One paper (A.W. Mabbitt *et al.*, Plessey Co., Towcester, UK) described work on small area (50 μm) high radiance, large bandwidth LEDs for fiber optics applications, fabricated from GaAs and GaInAs. The latter material might allow for greater fiber link lengths, since the fiber attenuation and dispersion are lower at 1.06 than at 0.9 μm wavelength. Many of the papers were concerned with failure modes of LEDs, and means were discussed for increasing reliability and lifetime of these devices.

The Symposium demonstrated that progress toward the realization of a wide range of devices based on GaAs and related compounds has been steady, if unspectacular. Much work remains to be done, even in the successful fields of LEDs and microwave FETs,

and much of this will need to be concerned with materials growth and characterization, and with methods and consequences of processing. (R. Kaplan, NRL, currently on leave at the Clarendon Laboratory, U. Oxford)

GAS TURBINE MATERIALS IN A MARINE ENVIRONMENT

The Third Conference on Gas Turbine Materials in a Marine Environment was held in England at the University of Bath, 20-23 September 1976. This Conference was jointly sponsored by the US Naval Ship Engineering Center (Hyattsville, MD) and the UK Ship Department at Bath. The general purpose was to present current progress relating to the complex interdisciplinary problem of extending the operating life of gas turbines at sea. Both the US and UK Navies are particularly interested in this subject since aero-derived gas turbines will power many of the light- and intermediate-weight ships in future fleets.

Attendance at this meeting was restricted to government defense agencies and their contractors actively involved in gas turbine materials research. Of the 138 registered participants, only approximately 30% were from the US. There were 45 invited papers presented in 7 different sessions over a 3-day period. The session topics were as follows: Service Experience in the Marine Environment; Air and Fuel Filtration and Inhibition of Corrosion by Fuel Additives; Testing and Evaluation of Materials and Coatings; Ceramics for Gas Turbines; Degradation Mechanisms; Materials and Coatings Developments; Fabrication Techniques. A general discussion and listening panel report concluded the Conference. Optional visits to several British gas turbine manufacturers and materials research groups were also organized for non-UK participants during the following week. Since complete papers will be published in the Conference Proceedings early in 1977, only the general aspects of the meeting will be commented on here. [Contact Mr. John W. Fairbanks, Naval Ship Engineering Center (6146B), Hyattsville, MD 20782 or Mr. Len Wortley, Ministry of Defence, Bath, England, BA2 7AY, for copies.]

The true success of this meeting must be evaluated as a summation of progress in each of the many areas of specialization which are being applied to the marine gas turbine problem. When evaluating the results from different laboratories, overall progress is difficult to determine. For example, in metallurgy, a wide variety of alloys are being tested in several types of burner rig which attempt to simulate turbine operating conditions. In the past, perhaps too much concern was given to quantitative differences. After this Conference, the general consensus was that during the last 2 years, there has been more agreement on testing results and corrosion mechanisms. Although this is encouraging, the fact remains that gas turbine propulsion units on ships still require relatively frequent and costly maintenance.

Most of the damage to marine gas turbines is ultimately linked to aerosols (sea salt, continental dust and other atmospheric particulates) which cause compressor fouling and corrosion or erosion of turbine components. Unless both the intake of marine aerosols and the presence of certain impurities in the fuel can be appropriately reduced, high-temperature (above approx. 800 C) corrosion of metallic gas turbine components will continue to occur. It is expected that ceramic coatings and ceramic turbine blades will eventually solve much of the corrosion problem. However, the intake of aerosols must still be controlled to the extent that appreciable salt deposition does not occur inside the turbine. A future goal is to raise the maximum operating temperature from 1100° to 1370°C, thereby realizing a 40% increase in efficiency. Again, ceramic components may play a significant part in achieving this goal.

There are tentative plans to convene another US/UK gas turbine conference in the northeastern US within the next 18 months. (F.K. Lepple, Naval Research Laboratory, Washington, DC)

ONRL REPORTS

See the back of this issue for a list of current abstracts, and how to obtain the reports.

CHOOSING THE OPTIMUM MATERIAL: AN ENGINEER'S AID

At a recent meeting of the Institute of Physics in London on information and the industrial scientist, the Fulmer Research Institute exhibited its "Materials Optimizer," which it describes as a "materials information system for the selection and specification of engineering materials...(for) designers, engineers, purchasing managers, and anyone whose job it is to obtain maximum value from engineering materials." The "Optimizer" represents a 2-year effort of about 25 materials specialists at Fulmer under the direction of N.A. Waterman, editor and project manager, working in cooperation with industrial materials suppliers and processors.

The heart of the system is a 4-volume loose-leaf set of summary graphs, tables and text on the performance and current costs of metals, plastics, ceramics and their related component manufacturing processes. The system has been designed to permit a comparison of candidate materials available for any given application and a quick selection of those which are most appropriate from property, processing or economic criteria. Information is regularly up-dated (cost information, for example, is reviewed at least twice a year), with new materials and processes being added as they become available and case histories being given of new applications of existing materials.

A better appreciation of the system's coverage may be obtained by a brief summary of the contents of the various volumes. Vol. I, "Comparison of Materials", deals with strength of materials, including fracture-toughness, fatigue and creep; corrosion, wear, and other causes of degradation and methods for their prevention, including coatings; and forming and joining of metals, plastics and ceramics. Vol. II, "Characterisation and Specification of Metals", covers all metals of interest from ferrous, non-ferrous metals and alloys through precious and refractory metals. Vol. III on "Non-metals" deals with all commercially available polymeric materials, ceramics (including design principles for their use) and high-performance composites. Vol. IV, "Material Selection System and Examples", gives instruction on design analysis and materials selection.

The set, with service updating it through March 1977, is available at £350 directly from the Fulmer Research Institute Ltd., Stoke Poges, Slough, Bucks. SL2 4QD, UK. (J.H. Schulman)

THE IMPORTANCE OF BEING DEFECTIVE

"Zero defects" may be a gung-ho motto to inspire a production line, but if crystalline solids could exist only with zero defects, production lines for certain kinds of devices--transistors, fluorescent screens, photographic film, and solid-state lasers, to name just a few--might never have come into being at all. Because solids are rather susceptible to the occurrence of atomic-scale defects in their structures--impurity atoms, vacant lattice sites, interstitial atoms, and aggregations of these imperfections--they are actually much more interesting and versatile materials than they would otherwise be. Thus, the useful electronic and optical behavior of insulating and semiconducting crystals comes about, in the vast majority of cases, from imperfections built into them in a controlled fashion; these defects exert an influence on physical properties quite out of proportion to the low concentrations in which they are incorporated. On the other hand, uncontrolled types and concentrations of defects can (and usually do) have a deleterious effect on the peroformance of solid-state materials, whatever their application.

Testifying to the fundamental and practical importance of the subject, there were two international conferences on defects in solids within the space of two weeks in the autumn in Europe: the 2nd Europhysical Topical Conference on Lattice Defects in Ionic Crystals (Berlin, 30 August - 3 September) and the International Conference on Radiation Effects in Semiconductors (Dubrovnik, 6-9 September), which was in essence a conference on defects in semiconductors. Although the two symposia focused attention on different classes of materials, they had much in common when it came to the basic questions asked (configurations or models of the defects, mechanisms of defect formation and effects on properties) and the major research techniques employed

(optical and ESR spectroscopy, conductivity, luminescence, annealing studies, etc.). A few preliminary comments on both meetings might, therefore, be in order here pending the appearance of longer separate ONRL Reports now in preparation.

Both conferences featured several plenary tutorial and review lectures, most of which were not only scholarly and comprehensive but also very lucid. Because of its size and diversity (more than 200 participants and well over 150 papers) the Berlin Conference required parallel sessions, one group dealing primarily with the ionic and structural properties of defects (emphasis on diffusion, ionic conductivity, radiation damage) and the other group concentrating on electronic properties (emphasis on such things as color centers, luminescence). The Dubrovnik Conference, a little more than half the size both in numbers of participants and papers, managed to get along without parallel sessions, but included a small poster session. The Proceedings of the Berlin conference are to be published by the *Journal de Physique*; those of the Dubrovnik conference will be published in the Conference Series of the Institute of Physics (London). Prices and publication dates are not known at this writing. The overlap of interests between the two conferences can probably best be illustrated by interleaving comments about a few papers from both meetings.

Ion-implantation methods for semiconductor device fabrication (see ESN 30-2:73 and ONRL Report C-3-76) yield a sharper impurity-concentration profile than the conventional diffusion processes and hence are seeing increased use. The implantation process, however, produces radiation damage, forming displaced atoms, vacancies and other defects whose behavior must be understood and controlled. According to J.W. Corbett (Albany), who opened the Dubrovnik conference with a review of defects in silicon, radiation damage studies in semiconductors have been going on for about as long as the transistor has existed. Although we consequently know a great deal about defects in these materials, much more information is needed to help make devices cheaper, better and defect-free. Corbett speculated that, with more knowledge, one might eventually be able to introduce a "defect-annihilation" center for vacancies or interstitials, and he forecast the eventual evolution of "defect engineering."

The opening lecture of the Berlin conference was given by Professor A. Guinier (Orsay) under the provocative title "Can we see lattice defects in crystals?" Despite the fact that his answer to the question was "Yes" in one sense and "No" in another, Guinier's lecture was a model of clear exposition of our present ability to find the structure of defects by imaging or diffraction methods. With the electron microscope one can normally see images of defects greater than about 10 Å in size, such as vacancy clusters or dislocation loops; in specially favorable circumstances one can resolve striations separated by about 4 Å, viz., in crystallographic shear planes from non-stoichiometric defects in Nb and V oxides; and in V_7S_8 one can even see the vacancy spots predicted by computer simulation. With x-rays, one is confined to diffraction studies, which give only the average environment around a defect, whose presence is evidenced by diffuse scattering outside of the Bragg reflections which arise from the perfect crystal. One must first postulate models of the defects and then check them against observation. With the powerful x-ray sources and better detectors now available one can detect 10^{-3} - 10^{-4} mole fraction of defects. Moreover, the advent of synchrotron radiation makes possible another x-ray approach, EXAFS (Extended X-ray Absorption Fine Structure) which can give similar information. These ideas were developed further in a subsequent invited plenary talk by J. Peisl (Ludwig Maximilian's University, Munich), who predicted that the further exploitation of diffraction methods would lead to a type of "x-ray defectography" which would allow one to "zero-in" directly onto the structural description of defects.

This time has not yet arrived, however, or so it would seem judging from a very vigorous exchange between A. Seeger (Stuttgart) and J. Van Vechten (IBM, Yorktown) on the matter of the interpretation of "swirl" defects in silicon, the major topic of an invited paper by the former at the Dubrovnik meeting. These defects can be observed in dislocation-free high-purity silicon by x-ray topography, and the most

favored hypothesis regarding their structure was that they are clusters of vacancies forming dislocation loops. Seeger devoted most of his lecture to report that recent electron microscope and other work in his laboratory proves that these defects are due to Si interstitials, not vacancies. Seeger's conclusion was vigorously disputed by Van Vechten, who gave a very incisive impromptu lecture about the limitations on what can be concluded from e-microscope and similar images. He pointed out that the observation that lattice planes expand cannot be taken as firm evidence of the existence of interstitials. The controversy was not settled at the meeting, both sides refusing to give ground.

Another controversial Van Vechten idea--the existence of anti-site defects in compound semiconductors--was confirmed in an exciting post-deadline paper by Prof. J. Schneider *et al.* (Inst. of Applied Solid-State Physics, Freiburg). From ESR studies these investigators concluded that the defect, P on a Ga site, exists in GaP. Similar anti-site P was found in $CdSiP_2$ and $CdGeP_2$, where P replaces Si and Ge respectively. If anti-site defects prove to be as widespread and as high in concentration as Van Vechten has predicted, their existence will have to be taken into account in all aspects of work with compound semiconductors.

The foregoing results illustrate, once again, the enormous power of ESR to reveal the structure of defects in favorable cases. As workers in the field of color centers know, ESR studies completely revolutionized the picture of V-centers (trapped-hole centers) in alkali halides; in the late '50s W. Känzig (then with U. Illinois, Urbana, and GE, Schenectady; now of ETH, Zürich) and co-workers showed that the fundamental radiation-induced defects in these salts, the "H" center and the "V_K" center, do not involve vacancies but instead are halogen molecule-ions (X_2^-) occupying, respectively, a single anion site and two adjacent anion sites. Similarly, G. Watkins (then with GE, Schenectady, now of Lehigh U.) was a leader in elucidating the structure of defects in Si using ESR. Each of these major contributors gave invited papers at one of the conferences.

How remarkably far ESR methods have been exploited in the alkali halides since Känzig's pioneer work was shown in a plenary lecture at the Berlin meeting by Dr. D. Schoemaker (U. Antwerp) to which he gave the last-minute title of "Games People Play with Interstitials." Starting from a review of the structure of the H center (which, of course, is a kind of interstitial halogen) in pure alkali halides, Schoemaker described the amazing variety of modified H centers one can form by doping the crystal with foreign halogen, alkali, or other impurity ions. These modified H centers--some consisting of mixed halogen molecule ions (e.g., ClF^- rather than Cl_2^-), others consisting of H centers formed near impurity alkali ions--are often more thermally stable than the normal H center, and they display an interesting variety of symmetries and vibrational motions. The power of ESR methods was referred to at Dubrovnik, as well, where it was repeatedly pointed out that the much better information we have on defects in Si than those in Ge, III-V, or II-VI compounds is due to the accessibility of the former to ESR studies, whereas the latter are generally not as amenable to this approach.

Within the past few years new capacitance-change methods of characterizing traps in semiconductors have been developed, the most versatile and powerful one being the so-called "Deep-Level Transient Spectroscopy" (DLTS) developed by D.V. Lang (Bell Labs) [*J. Appl. Phys.* 45, 3023 (1974)]. By this method the position and depth of trapping levels, their concentrations, and electron or hole capture cross-sections can be determined even for deep traps whether they form radiative or non-radiative centers. Lang and his colleague, L.C. Kimmerling, both gave papers which reported extensive information obtained by this technique, Kimmerling concentrating on defects in electron-irradiated Si while Lang's invited paper dealt with a review of GaAs and III-V compounds in general. Lang pointed out that the behavior of these materials is more like that of the II-VI compounds (i.e., ZnS, ZnSe) rather than Si and Ge. All defects in GaAs and GaP show the phenomenon of recombination-enhanced motion, and Lang reported on work which showed that lattice-relaxation multiphonon emission is the mechanism behind this enhanced motion. The phenomenon here is very similar to the well-known Pooley-Hersh mechanism pro-

proposed for the formation of H-centers by x-irradiation of alkali halides.

The main impression gained from the Dubrovnik conference is that there is an enormous amount of work yet to be done to understand defects in other semiconductors as well as one does in Si. For example, our knowledge of defects even in Ge is in its infancy compared to that in Si. The Berlin conference underscored the intense interest that still exists in Europe in studies of defects in ionic solids, a topic that does not seem to engage the attention of American researchers quite as much as it once did.

The closing plenary lecture in Berlin by E. Sonder (Oak Ridge) offered food for thought to those now working in the field, and it is also worthy of the attention of those who are tempted to discount this area of solid-state research. Sonder reminded his listeners that fundamental studies of defects in model ionic systems, such as the alkali halides, have provided the techniques and concepts needed to deal with more practical materials. Noting that the concepts based on research in these simple systems have been extended to more complex materials like CaF_2 and Al_2O_3, Sonder pointed out the need to push defect studies even further--to other refractory oxides, carbides, nitrides, and ceramic compounds that will be required for critical structural components of gas turbines, fission and fusion reactors, and magnetohydrodynamic generators now being looked to as solutions of the world's energy problems. In these systems high temperatures are often associated with other extreme conditions, such as large thermal and electrical gradients which cause directed ion migration and alter the properties of the material, as well as high intensity bombardment by nuclear radiations which produce defects by ionization and displacement processes. Our ignorance of these materials is vast, and if we are to realize the ambitious energy-generating systems mentioned above, we must know more about the heat- and radiation-resistant materials that they will require. (J.H. Schulman; L.M. Slifkin, U. North Carolina, Chapel Hill; N.D. Wilsey, NRL, Washington, DC)

MATHEMATICS

THE LEICESTER CONFERENCE ON CONTROL THEORY

A 3-day meeting on the topic "Recent Theoretical Developments in Control" was held in the old English market city of Leicester on 14-16 September, about 2 weeks prior to the opening of the UK academic year. Professor T.V. Davies (U. Leicester) was the principal organizer and the host for the Conference, which was sponsored by the UK's nearly 7000-member Institute for Mathematics and its Applications (IMA). This was a follow-up to the IMA-sponsored meeting at the University of Bath in 1972, the Proceedings of which were published under the title *Recent Mathematical Developments in Control* (D.J. Bell, ed.; Academic Press, 1973). The scope of the 1976 Conference, in contrast to specialized one-day seminars held occasionally by the Control Group of IMA, was the complete spectrum of current research activity in the mathematical theory of control.

Although the Conference was open to the international mathematics community, surprisingly few of the approximately 90 participants were from outside the UK. (By my count, there were 3 representatives from Western Europe, 2 from Japan and only myself from the US.) All of the leading British research centers in control theory were represented. About 20 of the registrants were from industrial organizations, the rest being from the academic community.

Of the 35 papers presented in the 3 days, 34 were half-hour contributed papers which had survived a preliminary screening by the organizing committee. Unlike the 1972 Conference at which 8 speakers were invited to give survey coverage of the various subareas of control, the Leicester meeting featured only one invited speaker: Professor H.H. Rosenbrock, Director of the Control Systems Center of the University of Manchester's Institute of Science and Technology (UMIST). Rosenbrock, recently elected a Fellow of the Royal Society, delivered an excellent state-of-the-art presentation on the "Algebraic Theory

of Linear Systems." The basic goal of the work that he described is to reconcile the "modern" theory of control with the "classical" theory.

In classical control theory, the input to and output from the feedback control system are related to one another via the system's transfer function. The analytical tools associated with this theory are the familiar Laplace transform techniques combined with frequency-response and root-loci methods for systems analysis. While such an input-output model is normally the most direct and easily formulated mathematical expression of the system's behavior, it is of limited applicability since it contains no information regarding the internal state of the system. Moreover, the analysis of a system described in transfer function form is basically a trial-and-error procedure which cannot be expected to lead to an optimally designed system. In contrast, the modern theory of control stipulates that the system is modeled in what is termed "state-space" form. The "state model" relates the system's input and output via a detailed mathematical description of the time-dependent internal states of the system's components. In addition to being a more complete and mathematically elegant representation than the transfer-function model, the state-space model has the virtue of being in a canonical mathematical form to which powerful analytical methods and numerical solution techniques can be directly and systematically applied.

An obvious difficulty in applying modern control theoretic techniques to the analysis of real-world control systems is that the mathematical model is almost never *a priori* formulated in state-space form and must, therefore, somehow be manipulated in order to achieve a canonical representation.

The work which Rosenbrock described is concerned with the important and very practical problem of developing systematic, computer programmable techniques for the automatic transformation of a given (linear) system into state-space form. His approach to this problem is based on what is referred to as the "polynomial matrix theory" which he and others have developed over the past several years. This theory emerged from his careful study and formalization of the *ad hoc* methods used by engineers to transform a given system description into state-space form. Rosenbrock claims that these general polynomial matrix transformation techniques can be embodied in a computer program which will automatically translate a given system description into canonical state-space form.

In addition to providing a summary of his own contributions to algebraic systems theory, Rosenbrock also described some very recent work by P.A. Fuhrmann which is scheduled to appear in the next issue of the *International Journal on Control*. In this, Fuhrmann demonstrates how, by weakening the hypotheses of Rosenbrock's polynomial matrix theory, it is possible to develop an operational calculus which embodies virtually all the transformation and substitution tricks which engineers employ in deriving state-space equations.

The practical significance of these developments in algebraic systems theory is that the important questions of controllability (the ability to change the system from any given initial state to any desired final state) and observability (the ability to determine the internal state of the system from observation of its output) can be studied analytically for even rather large and complex control systems. This, claims Rosenbrock, is not possible with the Kalman Module Theory, which starts with an essentially external description of the system. He concludes that the theory is now in sight of the objective of a unified approach which will encompass all of the existing "partial" theories, but that this will probably require several more years of work.

Algebraic systems theory, the subject of Rosenbrock's presentation, is only one of several major problem areas into which modern control theory is divided. Other subareas are: optimal control methods; system identification techniques; stochastic control; filtering theory; and stability of non-linear systems. The field is also broken down according to the type of the describing differential equation: lumped systems (systems of ordinary differential equations); distributed parameter systems (systems described by partial differential equations); and delayed systems (described by either ordinary or partial differential equations with time lags). Unfortunately, Rosenbrock's invited presentation was the only lecture which attempted

to survey the state-of-the-art in any specific area. For the most part, the contributed papers consisted of detailed expositions of scattered results.

Since the proceedings will be available to the interested specialist, it seems advisable here to limit remarks to those papers which seemed to provoke greatest interest or indicate new trends. One such paper is that presented by R.F. Curtain and A.J. Pritchard (Control Theory Centre, U. Warwick). This, entitled "A Semigroup Approach to Infinite Dimensional Systems Theory," discussed the unity of mathematical structure which can be gained by abstracting a linear model of a control system (whether it be lumped, distributed or delayed) to an abstract evolution equation on an infinite dimensional space where the solution to the evolution equation will be a semigroup. In a very well-delivered presentation, Pritchard showed how this abstract but unifying approach enables the main system theory questions of controllability, observability, stability, estimation, etc., to be treated in a more general setting than the classical techniques permit. Examples were given of mathematically abstract results which, when properly specialized, reduce to well-known results concerning the various differential equation types of systems.

Another paper which exemplifies the extent to which certain researchers are attempting to "elevate" control theory from its engineering foundations is that of J.E. Rubio (U. Leeds): "On Optimal Control Problems in Hilbert Spaces: The Case of the Unbounded Controls." By making certain straightforward identifications between standard control theoretic concepts and the standard tools of measure theory, Rubio was able to deduce, with the aid of a weak-star topology convergence argument, a theorem on the existence of certain abstract types of control. The 3 or 4 papers of this sort which relied heavily on overly formal mathematical machinery received a very cold reception from the vast majority of the audience. In these presentations, one could not help feeling that the authors had totally lost touch with the real-world applications of control theory.

Few of the papers were directly concerned with or motivated by real-world problems. Two notable exceptions were the contributions of A. Machado and D.J. Bell (UMIST): "The Computation of a Singular Control for a Stirred Reactor" and that of S.P. Banks (U. Warwick): "The Stability of a Non-Linear Frequency Controlled Network". In the first, the authors compute the optimal "bang-bang" (on-off sequence) control trajectory required for the minimization of the extent of reaction in a stirred chemical reactor tank. Their technique demonstrates, for the first time, how to test for the optimality or non-optimality of various candidate control trajectories. Such problems are of considerable industrial importance and hence Machado and Bell's results should be of interest to the control engineer.

The paper by Banks reports a study undertaken at the request of the UK's General Post Office (GPO) which controls not only the postal services, but also the nation's telephone and telegraph systems. The problem which arises is that of analyzing the stability of a newly developed system for digital data transmission through telephone exchanges. In this network, each pair of exchanges is connected by a non-linear, time-delayed control system which is "bilateral" in the sense that oscillator i controls oscillator j and vice versa. In the special case of a hierarchical system, only j (for example) would be controlled, and the feedback loop in the ith exchange would be eliminated. The details of the model are quite involved, and it is not possible to obtain directly a stability criterion for the general case of an arbitrarily-connected network. However, by a careful analysis of systems whose graph structure is a tree (i.e., has no circuits among its interconnections) and a proof that, for stability purposes, the general bilateral system is equivalent to one whose graph is a tree, Banks is able to reduce any given bilateral network to one for which stability criteria are obtainable. The results show that stability of the general system is highly dependent on the network topology. The GPO is now using these results in the design and analysis of feasible networks.

A paper by D.N. Burghes and R. Davison (Cranfield Institute of Technology, Bedford), entitled: "Optimal

Control of Deterministic Models in Economic Growth Theory", attracted a great deal of interest and criticism. The basic problem which the authors considered was the following: Given a deterministic model of economic growth, find the optimal control (i.e., the time-dependent, vector-valued control function) which should be followed by the economic planners so as to maximize a certain "welfare integral." The hostile reaction from the Conference participants seemed to reflect their personal frustration at the present state of the British economy and their lack of confidence in the forecasting ability of economic models. From a purely technical viewpoint, I could see nothing new in the Burghes-Davison paper.

The proceedings of the Conference will contain the full texts of all 35 of the papers presented. It will be published by Academic Press in about 6 months under the title *Recent Theoretical Developments in Control*. (W.J. Gordon)

OCEAN SCIENCES

EUROPEAN UNDERSEA BIOMEDICAL SOCIETY: ANNUAL SCIENTIFIC MEETING

ESN readers interested in underwater and hyperbaric medicine will be glad to know that the EUBS has been resuscitated and appears to be on the road to recovery. The Society was founded in 1971 to promote scientific communication among European specialists in the field, primarily by holding scientific meetings. The first such conference was a comprehensive symposium of high quality held in Stockholm in 1973 (ESN 27-7:161). The second, held in Copenhagen in 1974 (ESN 28-8:287), was a disappointing one-day affair. No meeting was held in 1975 because of the triennial Underwater Physiology Symposium.

Somehow, over the past two years the lines of formal communication within the EUBS (mainly the mailing list) have fallen into disarray. Early in 1976, an "action group" of EUBS members and friends of the Society managed to put in motion arrangements for a meeting at which new officers could be elected and the Society's affairs set in order.

The efforts were rewarded by an impressive turnout of 88 at a combined business and scientific meeting held 22-23 September at Newcastle upon Tyne. Local arrangements were managed by Dr. R.I. McCallum (Dept. Occupational He Health and Hygiene, Newcastle upon Tyne). During the business meeting, new officers were elected for terms of 3 years. The President is Dr. Xavier Fructus (COMEX, Marseille). The mailing address for the Society will be in care of Surg. Lt. Cdr. David Leitch, RN, Treasurer and Membership Secretary, Institute of Naval Medicine, Alverstoke, Gosport, Hants, England, PO12 2DL.

The consensus of the Executive Committee seems to be that the Society should function as a medium for scientific communication, primarily through annual meetings. The next meeting, in fact, has already been arranged for Toulon, France, 15 and 16 July 1977. The Society will also make recommendations on standards or procedures and will hold occasional workshops addressing specific problems, such as the one held in London last February on the treatment of decompression sickness (ONR London Conference Report C-18-76). The Executive seems determined, however, to avoid entanglement in the implementation of standards, drafting of legislation or management of training programs. The Society will no longer have any formal affiliation with the American-based Undersea Medical Society (UMS), as action taken by the UMS has eliminated the financial advantage of the previous arrangement. There will be no official EUBS scientific journal, but members were advised that a new publication based in France has absorbed the old *Bull. Med. Sub. Hyp.* The first issue should appear shortly of this *Journal de Médecine Aéronautique et Spatiale et de Médecine Subaquatique et Hyperbare*. The journal will accept articles in French or English, with abstracts in both.

Scientific Sessions--The scientific program was worthwhile, although it was clearly designed to justify the business meeting. The first day consisted of discussions of medical standards for diving, the formal presentations being, in fact, the preliminary reports of subgroups of the EUBS Committee on Medical Standards for Diving. The program was introduced

by outgoing President Klaus Seeman, who reminded the audience that the Society was seeking to establish no more than minimum standards. After revision, these reports will be made public as advisory documents only. However, many governments in Europe and elsewhere are involved in legislation regulating the diving industry, and recommendations of bodies like the EUBS and UMS carry great weight for good or ill.

For any reader interested in further information about these standards, the chairmen of the various subcommittees and their addresses can be obtained by writing to the Society at the address given above.

The final day's session was devoted to dysbaric osteonecrosis. The session proved to be a comprehensive and worthwhile review of the subject, with some interesting updates on current research. Dysbaric osteonecrosis (or aseptic bone necrosis) refers to the bone scars which are found in divers and compressed air workers. The disease may be without any apparent harmful effect in the majority of cases discovered in x-ray surveys, but it can occasionally progress to disabling disruption of joints. The bone lesion appears to be the local aftermath of decompression sickness (DCS), but this relationship is far from proven.

The University of Newcastle upon Tyne has been well known for years as the center for the study of dysbaric osteonecrosis in compressed air workers. All of the day's presentations except one were given by members of the Newcastle group. Research at Newcastle is funded mainly by the Medical Research Council Decompression Sickness Panel. The research team is housed within the Dept. of Surgery (Professor Walder) and the Dept. of Occupational Health and Hygiene (Dr. R.I. McCallum). Their interest in bone necrosis and decompression sickness was solidified by the establishment, in 1964, of the MRC Decompression Sickness Central Registry (DCSCR), under Dr. P.D. Griffiths. The Registry serves to centralize collection of data on decompression sickness and bone necrosis in compressed air workers, and has in recent years begun to include commercial divers.

The first speaker, Surg. Commodore J.A.B. Harrison, Deputy Medical Director General of the Royal Navy, is one of the world's foremost authorities on the radiology of bone necrosis. He reviewed the radiologic diagnosis of the condition and discussed some of the pitfalls. Dr. C.K. Warwick of Newcastle also discussed radiological diagnosis.

Activities at the DCSCR were described by McCallum. The 1975 UK regulations governing commercial diving require annual x-ray surveys to detect bone necrosis in divers. The majority of these films are being voluntarily submitted to the Registry for expert interpretation and cataloging. The current rate is 200 films per month. Correlation of films with medical examinations and history data is now possible because the examiners are voluntarily submitting with the films a copy of the standard medical forms recommended by the Underwater Engineering Group of the Construction Industry Research and Information Association (CIRIA).

Mr. A. Evans gave an up-to-date analysis of the diver x-ray data. The Registry now contains films of 2516 divers, the majority of whom are new entries. The prevalence in this sample of definite bone necrosis is 2.38%. If suspected lesions are included, the figure is 4.21%. These rates are comparable to previous reports of divers in the RN and USN, but much lower than certain other groups, such as Japanese shellfish divers. (Such differences are generally presumed to reflect the adequacy of the decompression procedures used.) Where historical details were included with the films, confirmation was provided of trends seen in other studies. The prevalence of lesions increases with diving experience and/or age (6.42% in the over 40 age group). Lesions are rare in shallow air divers, and more common in deep helium and saturation diving. The prevalence is higher in divers with a history of DCS, and this correlation is more striking than in compressed air workers.

Mr. P. Trowbridge analyzed the films of 2200 compressed air workers in the Registry. Bone necrosis is more prevalent in this group--17% for definite lesions. The proportion of such lesions which underlie a joint surface (the potentially disabling ones) is much higher than in divers--36%. Correlation with age, experience, and history of DCS is again demonstrated. Computer storage and retrieval methods will eventually make it possible to identify workers in relation to the contracts under which they were exposed.

It will then be possible to correlate bone changes with specific day-to-day exposure histories and decompression tables.

Research into the cause and prevention of dysbaric osteonecrosis has always been hampered by the lack of a suitable animal model of the disease. Mr. P. Cox described the line of research being followed at Newcastle toward this end. They have tried to generate lesions by microvascular embolization, injecting suspensions of 60-μm glass spheres into the external iliac artery. In a total of 40 rabbits, lesions were produced in 12 femoral heads and 14 femoral shafts. X-ray changes were seen after 3 weeks, but cortical thickening was the only change. Unlike men, the rabbits always showed healing by complete revascularization. Structural collapse and marrow calcification were not seen. Whether this process is sufficiently analogous to bone necrosis in divers to be useful remains to be seen.

This embolization technique was used by Mr. C.R. Weatherly to study biochemical early indicators of bone damage. Since the change visible on x-ray is an end stage, early detection methods have been sought. Weatherly has measured the urinary excretion of hydroxyproline by rabbits after iliac artery embolization. This amino acid is utilized exclusively in the collagen of connective tissue, including bone matrix. Therefore, in bone destruction and healing, an increased excretion of hydroxyproline would be expected. Weatherly found a significant increase in excretion within 5 days after embolization, but only in rabbits which were later found to have bone lesions. However, during such experiments the dietary intake of hydroxyproline must be rigidly controlled, and this presents a serious limitation to the application of the technique to men.

Bone gamma-ray scintiscanning with technetium-99m was described by P.J. Gregg (Newcastle). In the same rabbit model, bone changes were demonstrated by scanning before x-ray evidence was seen. It was interesting to note that these scan changes were seen even in lesions which did not become visible on x-ray.

The meeting concluded with a showing of a new 20-min. video tape program on immersion hypothermia by Professor W.R. Keatinge (Dept. Physiology, London Hosp. Med. Coll.), with Surg. Cdr. Frank Golden, RN. The tape is really not up to the quality which might be expected of these two authorities, and the visual effects are not optimal. Nevertheless, the tape would be a useful teaching tool for scientific audiences and is available for rent from Keatinge. (LCDR K.M. Greene, Exchange Officer, Undersea Medicine, Institute of Naval Medicine, Alverstoke, UK)

MORE MARINE TECHNOLOGY

We have noted earlier the need being expressed in the UK for an increase in the interaction between industry and the academic community in the field of marine technology and for the development of a nationally coordinated program of research and training for this field (ESN 30-10:464). In this connection the Science Research Council (SRC) issued a Special Task Force report dated April 1976 calling for:

(1) An increased level of support by the SRC for marine technology mounting to £26 million over 5 years.

(2) A close working relationship between the academic institutions and industry in Marine Technology.

(3) Integration of the SRC supported program of longer term research and training with existing civil and defense efforts in the Marine Technology area, aiming at a coordinated national program.

(4) Establishment and support of a limited number of centers of expertise although the program should not be exclusive to these centers. Candidate centers are named.

(5) Research priorities in the following suggested areas: safety and instrumentation; underwater work and pipelines; floating craft and environmental forces; marine structures and materials; power generation and transmission; economics.

(6) Changes (unspecified) in SRC management and administration to achieve these ends.

(7) Broadening the scope of the review beyond the immediate problems associated with hydrocarbon extraction studied by the Task Force. The Task Force, however, considered that the immediate North Sea requirements realistically set the pattern for the broader spectrum.

Issuing the report the SRC specifically sought participation and comment

in order that a full program could be proposed. To promote further the required discussion and comment on the proposed national program the SRC now plans a number of meetings with the scientific community and other interested parties.

One such meeting was organized by the Society for Underwater Technology on 22 Oct 76 under the chairmanship of Professor Sir James Lighthill, FRS, the Society's President-elect. The degree of interest was evident from the attendance, which exceeded 150, with representation from a wide range of government bodies, industry, the academic community, banking, the scientific press and a number of professional bodies, including some, indeed, from overseas.

Opening the meeting Lighthill displayed considerable forethought and appreciation as he traced through the Task Force's report, identifying the principal controversial points as a basis for the subsequent discussion. These may be summarized as training, research requirements, centers of expertise, finance and SRC organization. He was followed by 3 principal speakers: Dr. Jack Birks, CBE, Technical Director, BP Trading Ltd., Chairman SRC Special Task Force; Sir Sam Edwards, FRS, Chairman, Science Research Council; George Williams, OBE, Director General, UK Offshore Operators Association. The first two are closely associated with the Task Force report and the third is a representative of industry.

Birks reviewed the history of the Task Force, the nature of the input information and its report's conclusions and recommendations. Stressing the question of academic involvement, he noted that since the report appeared specific operating difficulties in the North Sea have further emphasized the urgency of the need for their solution. They were said to include:

(1) The difficulty of environmental forecasting at sea. It was stated that in the previous weeks it had been predicted that operations would be possible for 20 days when, in fact, they had been limited to 3 days. Could forecasting be improved? Could one improve on operating techniques? What are the possibilities of wave suppression barriers?

(2) Corrosion which had received increasing recognition as a major operating problem (C.F. ESN 30-5:237)

(3) A pressing need for cheaper off-shore engineering.

(4) Rapid expansion of exploration and exploitation into new areas, calling for trained personnel, equipment and procedures.

Birks further emphasized the importance of marine technology to the UK not only in relation to the more immediate North Sea requirements but also by the UK's playing a leading worldwide role through its exportable technological expertise based on that experience.

Edwards outlined the SRC's role in support of longer term research and training. Almost certainly because of national press coverage that day, he then discussed the current financial problems of the SRC which are aggravated by the weakness of sterling. (It may be noted that of the SRC's financial resources of about £100 million per annun, 1/3 go to overseas commitments and equipment purchases. The press had reported that unless the mounting proportional costs of these, caused by the fall of sterling, could be reduced, it would be necessary to cut back existing projects such as astronomy and space, domestic high energy physics, experimental facilities, the number of studentships, etc.) The SRC itself supported the Task Force's report but wanted the opinion and comment of the community. Despite the financial climate, £6 M (over 5 years) which are in the SRC Engineering Board's kitty are being allocated initially against the £26 M estimate in the Task Force's outline plan. Additional funds would certainly be available as the program developed. Recognizing the importance of the requirement and the need for programming and direction, the SRC intends to depart from its normal procedure, as it has already done in the case of polymer engineering. A directorate will be established, and with industry's assistance the director will be provided with a small advisory committee with substantial industrial representation. It is hoped that industrial interest will be such that there will be some financial support. This is considered important, as it were, "to provide lubrication".

Williams regretted that he could not give the views of 140 firms, but he had attempted to get an oil industry view by asking comment on the report from twenty petroleum companies. In his view the general reaction was one of widespread interest, praise in

general outweighing criticism. There was some feeling, however, that the Task Force should have been set up earlier and that it would be difficult to catch up. He reviewed the wide range of comments received on the Task Force Report under three general headings:

A. Critical of omission or coverage:

1. The Task Force had undertaken too much in too short a time. Various quantitative assessments were in question or missing. For example, there is a shortage of engineers, but how many are required? Again it was difficult to assess the basis of the funding requirements.

2. Not enough attention had been given to other existing programs.

3. There was insufficient guidance for coordination. Other industries are involved besides oil.

4. Insufficient attention had been given to the weighting between research and training.

B. Critical of reasoning:

1. There was considerable belief that the Universities' first priority is training (education), then basic research, and after that applied research.

2. University research should complement rather than duplicate other efforts.

3. The research priorities suggested in the report were questioned.

4. Marine Technology appeared to have been confused with the technology of Oil Extraction.

C. Supporting:

1. Endorsement of the need to use university talents.

2. Support for stronger industry/university interaction; but this should be at the personal level.

3. Agreement with the concept of centers of expertise, although this could be a problem if the direction were too rigid.

Summarizing, industry generally displayed considerable interest in the proposals and willingness to cooperate. It endorsed the training role, but the research proposals were causing some concern and being questioned. Lighthill followed up on his opening remarks by ably organizing the ensuing discussion in terms of the controversial areas he had previously identified. At least 30 participants, many very well prepared and undoubtedly forwarned--and representing virtually all the professional groups represented at the meeting--contributed lively, spirited, critical, knowledgeable, and occasionally bitter comment perhaps best summarized in some of the closing remarks below.

Edwards, after thanking the participants for their valuable inputs, responded to specific comments. He first noted the difficulty and importance of the university-industrial interface. This is in part due to the British university system's being substantially different from that in Europe, the US or Japan. British industry is undoubtedly in comparison losing a major contribution, but techniques used in these other countries to effect interaction may not be directly applicable. He further noted that there is no intention to stop proposals of individual merit.

Lighthill, closing the meeting, called for greater precision (i) in recognition of the efforts required, (ii) as regards the centers of expertise, and (iii) in terms of the financial and organizational needs.

To these observers the prowess of the chairman and principal speakers in handling the difficult business of generating and responding to comment on national research policy and procedures in a public forum was remarkable. The limited discussion of the potential inputs of other government departments and the absence of any comment on the potential contribution and interest of defense was noteworthy and surprising, however.

Overall, there can be no doubt that within its available resources and to the degree that industrial cooperation is forthcoming the SRC will pursue a coordinated expanded program of research and training in marine technology. Indeed, grants are already being made. (A.W. Pryce and J.D. McKendrick)

ONRL REPORTS

See the back of this issue for a list of current abstracts, and how to obtain the reports.

PHYSICS

INTERNATIONAL CONFERENCE ON "APPLICATIONS OF HOLOGRAPHY AND OPTICAL DATA PROCESSING"

This Conference was held in Jerusalem, Israel, 23-26 August 1976, under the auspices of the International Commission for Optics and organized by the Israel Laser and Electro-optic Society. There were both invited talks and contributed papers attended by about 150 scientists from all over the world, and a small international exhibit.

The technical session was opened with a keynote address by Dr. E.N. Leith (U. Michigan) in which he discussed the present status of holography. He stressed the state-of-the-art in making and viewing white-light holograms and emphasized the works of S. Burton and L. Cross in connection with this.

Actually, Dr. S. Burton himself (Polaroid Corporation) gave a paper on this subject entitled "White Light Transmission/Reflection Holographic Imaging," which was one of the highlights of the meeting. By limiting the information content, i.e., the image depth, he is able to produce holograms which are brighter than the original object and can be easily seen against ambient room light. This is because they utilize the entire spectral output of the illumination source and diffract it into a fairly small solid angle. As these are surface-relief rather than white-light holograms which use volume diffraction, they can be mass-produced easily--another advantage of this system.

Holographic interferometry was the topic of 4 sessions; some of the applications discussed were in aerodynamic flow studies, 3-dimensional displacement, temperature fields, diffusion coefficient in water solutions, shear, and distribution of curvature and twist of plates. Non-linear effects in holographic interferometry and heterodyne interferometry were also discussed.

In the holographic recording materials session, H. Kurz (Philips GmbH Forschungslab., Hamburg) and J.P. Huignard *et al.* (Lab. Central de Recherches, Orsay, France), discussed in 2 separate papers the possibility of storage capacity in doped $LiNbO_3$ exceeding 1 Gbit/cm^3. Use of bismuth silicon and bismuth germanium oxides ($Bi_{12}SiO_{20}$-$Bi_{12}GeO_{20}$) as erasable storage material for phase-volume holography was discussed by Huignard and F. Micheron. They found these materials to have the highest photo-refractive sensitivity in crystals reported so far.

The non-optical holography session included papers on microwave holography in the design of glow discharge plasma lamps, for imaging of wind-generated water waves and through aberrating media by means of a phase modulated reference beam. One paper also discussed acoustical holography in detecting radiation sources.

In the sessions on image processing, it was felt that incoherent imaging has a definite edge over the coherent imaging, specially with reference to achievable signal-to-noise ratio. This was discussed in a paper entitled "Noise Problems in Optical Image Processing" by Prof. S. Lowenthal and P. Chavel (Inst. d'Optique, U. Paris-Sud, Orsay). Hybrid image-processing, where incoherent light is used in conjunction with electronic subsystems such as digital minicomputers or analog TV components, was also of special interest. In connection with hybrid systems, the paper entitled "A New Real-Time Non-Coherent Light Valve," by Dr. J. Orinberg *et al.* (Hughes), was received with enthusiasm. This device uses CdS photoconductor, CdTe light absorbing layer, dielectric mirror, and a liquid-crystal layer sandwiched between In_2O_3 transparent electrodes. Its performance is really outstanding: resolution 1000 lines/mm, input sensitivity 160 $\mu W/cm^2$ and contrast 100:1. Another real-time coherent optical data processor using nematic liquid crystal display as well as a real-time two-color incoherent-to-coherent PLZT image converter were also presented in separate papers.

The paper on the liquid-crystal valve, mentioned in the last paragraph, was actually presented in the Devices and Techniques session which included network methods for integrated optics, improvement of signal-to-noise ratio in an optical communciation system using surface acousto-optic real-time signal processors, and a simple way of making waveguides and gratings with possible automatic control by interferometers. In the field of pattern recognition, papers dealing with the

ancient handwritten Hebraic characters and optical writing appraisal were of interest. The biomedical application session included papers which dealt with the real-time automatic identification of biological specimens from their phase-contrast microscope pictures, automatic pattern recognition of pneumoconiosis, the black-lung disease of coal miners, using chest x-ray film, and the possibility of locating defects in middle-ear transmission without opening the tympanic cavity by using a double-pulsed ruby laser holographic system.

The above is a brief summary of the topics and papers, out of the approximately 85 papers presented, in which this author was interested. The organizing committee has promised to publish the proceedings very quickly, possibly by early 1977, in cooperation with Pergamon Press. These proceedings will contain all the papers in full detail.

There was one other feature of the meeting worthy of mention. The French group led by Prof. J. Ch. Vienot (U. Besançon) showed a slide and explained how they made a full-size hologram and its reconstruction of the Venus de Milo in the Louvre Museum by using the biggest photographic plates ever made (custom made by Agfa) and gallons of fixers and developers. This is the largest hologram which has ever been successfully made or even attempted. (P. Das, Electrical and Systems Engineering Dept., Rensselaer Polytechnic Institute, Troy, N.Y.)

NEWS & NOTES

PERSONAL

Dr. T.S. Blyth, Reader in the Department of Pure Mathematics, University of St. Andrews (Scotland) has been promoted to a personal chair.

At the University of Edinburgh, Dr. Bernard L. Ginsborg, Reader in the Department of Pharmacology, has been promoted to a personal Chair in pharmacology.

Dr. D.F. Bowns has been appointed Professor of Engineering at the University of Bath. He has been a staff member since the founding of the University and has been responsible for the teaching of control and systems engineering in the School of Engineering.

New members of the National Committee on Computer Networks are Professor R.F. Churchhouse, Head of the Department of Computing Mathematics, University College, Cardiff; Professor G. Black, Professor of Computation and Director of the Regional Computer Centre, University of Manchester; and Mr. D.W. Davies, Superintendent of the Division of Computer Science, National Physical Laboratory, Teddington, Middlesex.

Dr. George Gamlen, Academic Relations Manager, ICI Fibres Ltd., Harrogate, has been appointed Professor of Chemistry in the Department of Chemistry and Applied Chemistry, at the University of Salford.

Professor A.F. Gibson, Department of Physics, University of Essex, has been appointed as Head of the new Laser Division at the Rutherford Laboratory with effect from 1 January 1977. He will be responsible for the management of the Science Research Council's Laser Centre which is being equipped with an 800-GW neodymium glass laser for use by university students.

OBITUARY

Professor Leo Pincherle, Professor of Mathematical Physics, Bedford College, University of London, died on 25 October. He was a theoretical physicist and an authority on the electronic band structure of solids. Born and educated in Italy, he began his research work with Enrico Fermi at the University of Rome. In 1938, he and his family emigrated to England where he worked at King's College, London. In 1948 he was appointed Principal Scientific Officer at the Telecommunication Research Establishment (now RSRE), Great Malvern. Here he developed his theoretical calculations of electronic wave functions in solids. He returned to Bedford College in 1955 and was appointed Professor of Mathematical Physics in 1969. He was a visiting lecturer at the international summer schools in Italy, and gave

courses on the band structure of solids at the Enrico Fermi School in 1963 and at Perugia in 1966. He was the author of the book, *Electronic Energy Bands in Solids*, which was published in 1971.

ONRL REPORTS

R-10-76 EUROPEAN DEVELOPMENTS IN COMPUTATIONAL FLUID DYNAMICS by R.H. Nunn

In Europe, as in the US, the use of the computer to solve complex problems in fluid dynamics is a burgeoning field of endeavor. This report briefly describes some of the current European efforts in computational fluid dynamics. The citations are intended as "leads" to the individuals and institutions involved in such activities, and recent references are given to provide guidance to the latest published information.

C-26-76 THE 12TH INTERNATIONAL SYMPOSIUM ON APPLIED MILITARY PSYCHOLOGY by J.W. Miller

This report describes the 12th International Symposium on Applied Military Psychology, held in Paris in April 1976. The Symposium was attended by 24 representatives from 10 countries. The theme of the conference was "The contribution of psychologists to military effectiveness". Each participant was requested to bring examples of successful and unsuccessful programs which were initiated and/or implemented by behavioral scientists. Topics of discussion included recruitment and selection of armed forces personnel, training programs, conscientious objectors, the growth of unions in the armed forces, personnel research and training programs, leadership training, and the role of the psychologist in the armed forces. The 13th Symposium will be sponsored by Canada and be held at the Canadian Forces Base Europe, Lahr, FRG in April 1977.

C-30-76 THE 10TH INTERNATIONAL POWER SOURCES SYMPOSIUM by W.G. Soper

A summary is given of the 10th International Power Sources Symposium, Brighton, England, September 1976, at which 48 papers were presented. Emphasis in the review is placed upon secondary batteries with high energy density, i.e., those most suitable for electrically-powered vehicles. An introductory discussion of the principles of batteries and measures of performance is also included.

C-31-76 INTERNATIONAL SYMPOSIUM ON WIND ENERGY SYSTEMS by R.H. Nunn

This report offers brief descriptions of the papers presented in Cambridge on 7-9 September 76. Vertical- and horizontal-axis systems were discussed both in theory and in practice. Applications ranged from "wind forms" each with hundreds of megawatt units to the use of Cretan windmills to provide water for cattle. Wind energy conversion units have been operated in several configurations and the theory of their performances is sufficiently advanced to allow design for fabrication. The trends are towards larger units for municipal power systems and smaller units for domestic use. In the former case, the behavior of large wind turbines operating in large arrays, and the output (with and without storage) of several such arrays

C-31-76 (cont'd)

when geographically dispersed, has yet to be well understood. The field has reached a level of maturity characterized by such factors as economics, environmental impact, and public acceptance.

C-32-76

FROM SOUP TO NUTS--THE VIIth INTERNATIONAL CONGRESS ON RHEOLOGY by E.A. Kearsley

Brief summaries are given of many of the 270 papers presented and an effort has been made to develop an overall impression of what is going on in rheology these days. The report is meant to serve as a *Guide Michelin* to the tourist travelling through the Proceedings. Topical coverage includes constitutive equations for polymers, crystalline polymers, rubber elasticity, dilute solution theory, extensional and convergent flows of melts and solutions, chemorheology and aging, birefringence in polymers, block polymers, thermodynamics of viscoelasticity, rheological fluid mechanics, new devices and measurement techniques, technological polymer rheology, melt fracture, failure of plastics, drag reduction, biorheology, granular media, metals, paper and cloth, and gases.

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In ESN 30-11:504 we expressed our intention to publish an ONRL Report on the AGARD Conference on Applications of Non-Intrusive Instrumentation in Fluid Flow Research, held at the ISL in Saint-Louis, France, on 3-5 May 1976. Delays in preparation have now precluded the publication of this report, and interested readers are referred to AGARD CPP-193, "Applications of Non-Intrusive Instrumentation in Fluid Flow Research", which is available through NTIS.

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